

TRANSIT ORIENTED DESIGN AND URBAN DESIGN:

ESKİŞEHİR CASE – TRAM STOP ORIENTED

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TRAM STOP ORIENTED**

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ABSTRACT

TRANSIT ORIENTED DESIGN AND URBAN DESIGN: ESKİŞEHİR CASE – TRAM STOP ORIENTED

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Sustainable and public transportation plays a vital role in the cities to eliminate the disadvantages of urban sprawl. Transit oriented development (TOD) is one of the tools which is used to solve this problem. However, the efforts of TOD itself are not enough in order to increase the public transportation demand. TOD reaches significance when it is combined with the urban design since urban design defines both physical and personal factors in the point of creating effective TOD. For this reason, design factors also affect TOD to gain importance in respect to sustainable city and public transport in addition to TOD. On the other hand, the investments of rail systems have been increasing throughout the world. This is mainly because rail systems are the best alternative to reduce the usage of private cars. When station environment is supported with the urban design factors, tendency of people for walking and using the public transportation will increase. Consequently, it is seen that strong transportation model, urban planning and transportation modes that draw people's attention are required in order to change the travel behavior of people.

This thesis propounds that public transportation demand increases by combining the factors of TOD and urban design. These factors aim to make public transportation attractive for people by creating more usable tram stop environments. This thesis explains “New urbanism” which is the base of TOD and urban design besides the literature review of them. In addition, there are researches about design criteria for tram stop environment and stops. Under this purpose, Çarşı stop - the center of Eskişehir which has well-integrated transportation system and high public transportation demand has been selected as a case and it has been analyzed according to factors in literature review. The area of tramlines intersection is taken as a basis for case study in Eskişehir where the usage of tram is high.

As a result of these studies, it has been expounded with a case that TOD increases public transportation demand when it is supported with urban design.

Key words: Public transportation demand, Transit oriented development, Urban design, Tram stop environment, Eskişehir

ÖZ

ULAŞIM ODAKLI GELİŞME VE KENTSEL TASARIM: ESKİŞEHİR ÖRNEĞİ – TRAMVAY DURAĞI ODAKLI

Bahçeliođlu, İrem

Yüksek Lisans, Şehir ve Bölge Planlama-Kentsel Tasarım

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Sürdürülebilir ulaşım ve toplu taşıma, kentsel saçılmanın olumsuz etkilerini azaltmak için şehirlerde önemli bir rol oynamaktadır. Ulaşım odaklı gelişme modeli bunun araçlarından biridir. Ancak bu model toplu taşımaya olan talebi arttırmak için yeterli değildir. Ulaşım odaklı gelişme modeli kentsel tasarım elemanları ile birleştiđi zaman anlam kazanmaktadır çünkü kentsel tasarım, ulaşım odaklı gelişim için gerekli olan fiziksel etmenleri belirlerken kişisel etmenleri de belirlemektedir. Bu nedenle, ulaşım odaklı gelişme modelinin yanı sıra bunu etkileyen tasarım etmenleri de sürdürülebilir kent ve toplu ulaşım konusunda önem kazanmaktadır. Bunun yanı sıra, dünyada raylı sistemlere yapılan yatırım her geçen gün artmaktadır. Bunun en büyük nedeni raylı sistemlerin özel araç sahipliđini aza indirecek en iyi alternatif olmasıdır. İstasyon çevrelerinin kullanımı kentsel tasarım etmenleri ile desteklendiđinde, insanların toplu taşın kullanma ve yürüme eğilimleri artacaktır. Bunun sonucunda, insanların yolculuk davranışlarını deđiştirmek için güçlü bir ulaşım modeline, kent planlamasına ve insanları çekecek bir ulaşım türüne ihtiyaç olduđu görölmektedir.

Bu tez, ulařım odaklı gelişme ve kentsel tasarım etmenlerinin bir arada kullanılarak toplu taşıma talebinin artacağını ileri sürmektedir. Bu etmenlerin tramvay durak çevrelerini daha kullanılabilir kılarak, insanlar tarafından toplu taşıma cazip hale getirebilmesi amaçlanmaktadır. Tez; ulařım odaklı gelişme modeli ve tasarım etmenlerinin literatür taramasının yanı sıra bunların çıkış noktası olan “Yeni şehircilik” kavramını da açıklamaktadır. Bunlara ek olarak, tezde tramvay durak çevresi ve duraklarının tasarımına ilişkin de arařtırmalar bulunmaktadır. Bu amaçla, farklı ulařım türlerinin iyi entegre olduđu ve insanlar tarafından talebin fazla olduđu Eskişehir ilinin merkezi olan Çarşı durađı örnek olarak seçilmiş ve belirlenen etmenler doğrultusunda incelenmiştir. Özellikle tramvay kullanımının yoğun olduđu Eskişehir’de, tramvay duraklarının kesişimi olan alan baz alınarak arařtırma yapılmıştır.

Tüm bu arařtırmalar sonucunda, ulařım odaklı gelişmenin kentsel tasarımla desteklenerek toplu taşıma talebinin arttığı örnekle de açıklanmıştır.

Anahtar Kelimeler: Toplu taşıma talebi, Ulařım odaklı gelişme, Kentsel tasarım, Tramvay durak çevresi, Eskişehir

To My Whole Family...

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CHAPTER 1

INTRODUCTION

1.1 Definition of the Problem

There is a broad literature on the use of urban planning and design tools to make the city more sustainable. Transit oriented development (TOD) is one of these tools which entered the planning terminology in the late 1980s. In other words, TOD is one of the new urbanism trends which are based on humanistic urbanism. TOD proposes to concentrate residential and commercial areas around public transportation hubs and decrease the usage of automobile (Renne, 2005). It encourages people to live close to transit services and reduce the automobile dependency. TOD's benefits can be categorized as economic, environmental and social.

However, transit service environment in the walking distance is not given importance when TOD is implemented. In other words, the areas developing around the close environment of the transit services and their connection points are not considered. For this reason, people just notice the development area and designing tools are not paid attention. This situation decreases the usage of public transportation. Therefore, public transportation systems, development areas, and their connections should be integrated for reducing the car dependency.

TOD and urban design are two complementary concepts. In other words, to create a successful TOD, urban space should be well-defined with urban design criteria. Because if the area has only TOD's characteristics, it is hard to say that public transportation demand is high.

From this point of view, the main question of the thesis is "How public transportation demand can be increased by combining the factors of TOD and urban design?" Public transportation demand has different variables however time variability and time

reliability are the most important ones among these variables. Nevertheless, these elements are not enough by itself to increase public transportation demand. They should be supported by different planning and design tools. At this point, the elements of TOD and urban design gain importance. While preparing a TOD plan, it should be known that what kind of design tools should be used. This thesis aims to reveal how these elements are combined in areas having different characteristics.

Additionally, TOD and urban design are analyzed as tram stop oriented. Tram which is known as a nostalgic transport vehicle is defined as light rail transit, today. Within TOD and urban design contexts, the design of the tram stops' environment gains importance. This thesis aims to reveal how tram stops and their environment are designed within the contexts of TOD and urban design.

1.2 Aims and Research Questions of the Study

The main purpose of this study is to illustrate a theoretical framework about creating effective TOD combining with urban design criteria around tram stop. In this context, it is aimed to explain the factors that increase public transportation demand. It is known that the time variability and time reliability are not enough by itself to increase public transportation demand. Urban design has high importance to increase that demand. Hence, it is aimed to show the importance of the combination of TOD factors and urban design factors in the thesis.

For this purpose, a theoretical study about new urbanism, TOD and urban design elements are formed. First study is constructed with new urbanism which is significant to understand the importance of TOD. This study includes the occurrence of the term and principles of new urbanism. Second study is about TOD which should be understood clearly. For this reason, all factors of TOD, for instance public transportation modes, are analyzed. This study includes the definition of TOD, benefits of TOD, and factors and indicators of TOD such as density, land use & diversity and accessibility & connectivity. Therefore, this study shows the impressions of TOD on increasing public transportation demand. Third study is formed in the frame of TOD

design and urban design. This study includes TOD design guidelines and urban design factors affecting TOD. Within this context, physical factors and personal factors for urban design supporting TOD are identified. Designing tools are determined to create an effective TOD area. As a consequence of these studies, the concepts, tools and criteria of increasing public transportation demand by combining TOD and urban design are identified.

Within this theoretical context, Eskişehir, a Turkish city, is studied as a case. Eskişehir has a population of 826.716. It plays role as a bridge between Ankara and İstanbul. The origin of Eskişehir based on the Ancient and Medieval Ages. After the construction of railway, in 1890s, Eskişehir has developed rapidly. When the macroform development is analyzed, it is seen that first settlements are placed in İstiklal, Arifiye and Odunpazarı neighborhoods. Then it goes through the north east of the center to Şeker neighborhood. After 1970s, west part of the city has also started to develop.

Eskişehir is selected as a case in this study because it has well-integrated transportation system. Bus, tram, bicycle, private car and walking are the modes of transport in Eskişehir. Center area which is called as Çarşı is selected as a case area since it is the first settled area of Eskişehir. This area is analyzed in the contexts of TOD characteristics and design criteria. Çarşı being a center of the city is well-integrated place with different transportation modes. In there, TOD and design characteristics can be seen well. Moreover, this area is an intersection point of tramlines. This thesis aims to respond to the below questions thereby analyzing cases which have different characteristics:

- What are the main criteria to increase public transportation demand?
- What are the effects of urban design on public transportation demand?
- What are the criteria of TOD?
- What are the criteria of TOD design and urban design?
- Is TOD enough by itself to make public transportation attractive?
- What are the elements to make public transportation attractive?
- What are the dimensions (measures or criteria) of TOD?

- What are the design criteria for tram stops and their environment?

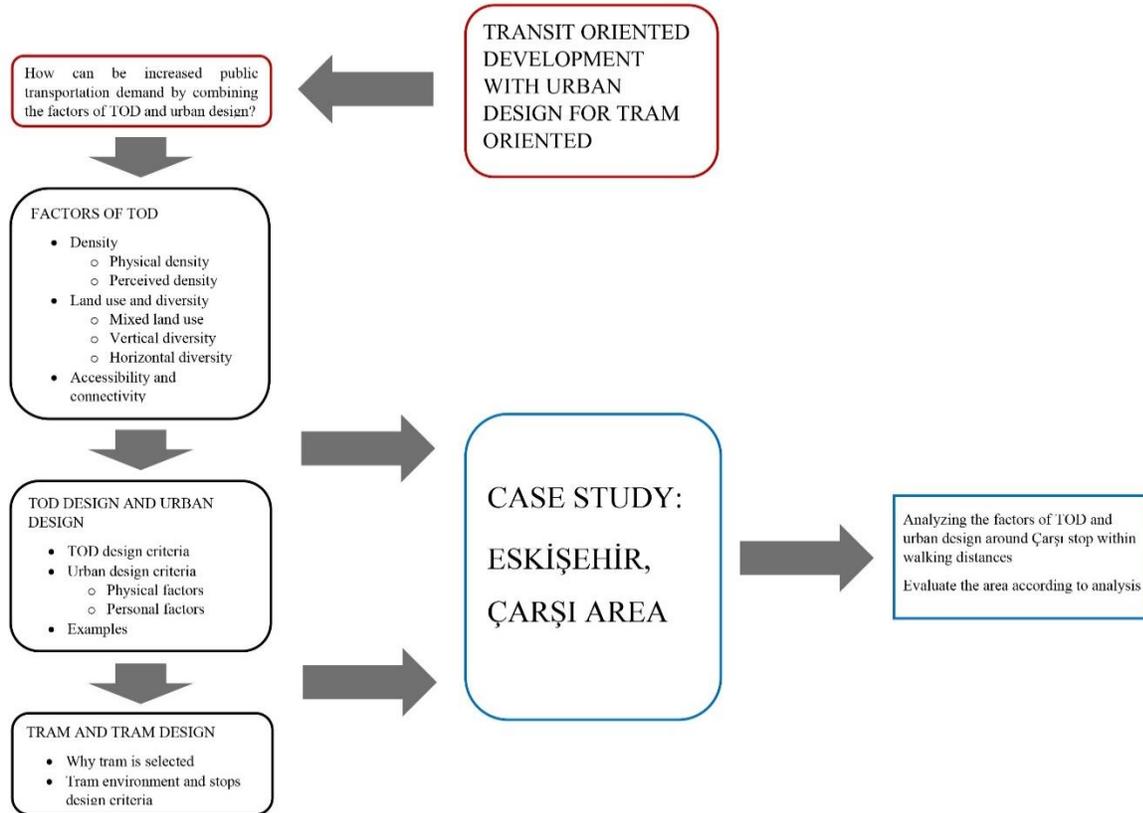


Figure 1-1 Aims of the thesis

1.3 The Research Methodology

A case study is used as the methodology in this study. Eskişehir is one of the most important cities where public transportation demand is high. Çarşı area which is the center of Eskişehir is analyzed in the direction of above-mentioned objectives. Before analyzing the area, theoretical background of the new urbanism and TOD are examined. Furthermore, the criteria of TOD design and criteria regarding the tram stop are investigated. With the aim of preparing the theoretical background, literature

review is made about the new urbanism, TOD and design criteria. Within this context, various books, many articles and reports are examined.

After understanding of theoretical framework, the case analysis is started. Before analyzing the area, Eskişehir should be known well. Therefore, general information such as location, population and names of neighborhoods is gathered from the available sources. After that, historical and spatial development of Eskişehir is examined by reviewing different sources and development plans. In addition to these, transportation modes in Eskişehir that are important to understand TOD characteristics are examined by gathering information from the web site of municipality and by formal researches.

The researches give an information to the readers about the area. Within this scope, the information is given about the location of the area, historical development of the area and common characteristics of the area. This information is gathered from satellite image, site analysis and formal resources.

Moreover, the factors increasing public transportation demands and tram stop designs are examined. According to these, the analysis are examined into 5 topics as density, land use & diversity, accessibility & connectivity, TOD design & urban design and tram stop & tram stops' environment design in Eskişehir. Within this context, each topic is examined within the scope of theoretical studies. Quantitative and qualitative data are used for this study. It is not possible to benefit from the similar studies for Eskişehir since there are not any yet. Besides collecting the data being essential, books, articles, reports and formal studies are examining. Direct observation is another method for analyzing Eskişehir. In the consequence of all researches, some photos are taken and some maps are prepared.

1.4 The Structure of the Thesis

The main hypothesis of the thesis is that transit oriented development (TOD) and urban design are inseparable elements for increasing public transportation demand. Within

this scope, this study proposes the research question: “How public transportation demand can be increased by combining the elements of TOD and urban design?” The elements of TOD and urban design should be understood in order to be able to answer this question. Moreover, tram is selected as a major transportation mode in this thesis because the design of tram and tram stops’ environment has importance.

In Chapter 2, New Urbanism is examined and occurrence and development of the term are explained. In addition, the principles of urbanism such as walkability, connectivity, sustainability and quality of life are simplified in this chapter.

Chapter 3 set the framework of TOD. The questions “What is public transportation?” and “What is the type of public transportation?” should be main questions regarding TOD at the beginning. In addition, the definition of TOD and its advantages should be understood in this chapter. There are some difficulties in the point of applying the TOD. These difficulties and their solution proposals are analyzed in this chapter. TOD is a live term because people’s behaviors affect the demand of travel. Because of that, the factors influencing TOD should be understood well. According to Cervero and Kockelman (1997), these factors can be defined as a dimension of the city. The important part of this chapter is to understand the measurement of these dimensions.

TOD design, urban design and tram design are examined in Chapter 4. First, TOD design dimensions, methods and their explanations are given in this chapter. Moreover, TOD design guidelines are defined. Furthermore, urban design is explained in this chapter. This explanation helps to answer the question of “What are the effects of urban design on public transportation demand?” This explanation also deals with the sustainability and new urbanism in the design context. Moreover, physical factors and personal factors of urban design are expounded in this chapter. Furthermore, tram design is explained in this chapter. This part includes technical information about tram, advantages of the tram and design guidelines for the environment of tram stops and stops. In addition to these, some practices for the urban design in TOD and transit station are given to explain design factors.

Chapter 5 is giving information about Eskişehir which is the focused city of this case study. Before analyzing a city in the framework of above-mentioned issues, it is important to know about historical and spatial developments of the city. Within this context, historical development of Eskişehir from primeval period to today and spatial development of Eskişehir such as microform development are explained. Four different periods are investigated within this concept. Moreover, for analyzing the TOD in Eskişehir, using modes and the modes' details should be known.

Chapter 6 reveals the case study which is investigated under the theoretical framework. Within this context, some information is given about selected area, which is called as Çarşı, in Eskişehir and they are visualized. Each factor is explained in a theoretical framework and analyzed for the case area. After the analysis, the answer for the hypothesis question can be found for the city of Eskişehir.

The conclusion, exposition and recommendation about the thesis are given in Chapter 7. Conclusion part includes the general summary of theoretical analysis of the thesis. In addition, there are results and comments about case study in exposition parts. Moreover, some recommendations are given about the answer of the main question of the thesis based on the case study.

CHAPTER 2

NEW URBANISM

In twentieth century, together with rapid urban growth and high use of automobiles in cities, new urban planning approaches and theories had been developed in order to control modern urbanization that create suburban limitless development, generating long trips between home and work as well as home and shopping or entertainment centers. New urbanism movement based on humanistic urbanism (Lehrer & Milgrom, 2009) was emerged. This movement known also as ‘neo-traditional planning’ has gained prominence as an alternative to modern urbanization. It is one of widespread attempts to solve problems of unsustain built environment and suburbanization that forms patterns of low-density land-use with high automobile-dependency.

In the 1980s, new urbanism had been made formal in the United States to develop local communities and promote the creation and restoration of walkable, compact, diverse, mixed-use communities. In new urbanization movement, the role of Congress for the New Urbanism (CNU), established by group of interested architects in 1993, is important. The members who have been individually worked for creating an environment with high-quality life designed a neighborhood unit according to traditional approach. The emphasis of the project was mixed land-use (www.newurbanism.org). In relation to new urbanization approach, the subjects of the First Congress, held in Alexandria, Virginia in 1993, were neighborhood, district, and corridor while the Second Congress, focused on buildings, blocks, and streets was organized in Los Angeles, California in 1994. New Urbanism is defined as a planning and development approach based on the principles such as walkable blocks and streets, housing and shopping in close proximity, and accessible public spaces. After 1993, different congresses have been held with different subjects (Rahnama, Roshani, Hassani, & Hossienpour, 2012). Besides the CNU has been working on a variety of

issues such as the environment, community development, education, and social equity and transportation (Ellis, 2002).

New urbanists defined a principle list. Some principles from the list are compact development to decrease the negative effects of urbanization on farmlands and environmentally sensitive areas; infill development in city centers; well-connected streets, pedestrian streets and bike paths; their integration with public transit system; mixed-land uses rather than single-use; transit-oriented development (TOD); well-designed public buildings and public places; the use of urban design to increase accessibility; green areas, parks and conservation lands to increase connectivity between city center and neighborhoods; and architectural design that reflects local and regional characters (Katz, 1994; CNU, 2000).

A 'Lexicon' for new urbanism has been prepared and updated by a company named Duany Plater-Zyberk (DPZ). As new urbanization focuses on both natural and human made environment for environmental sustainability, DPZ created design standards of a 'transect' for six zones ranging from rural to high-density urban (Lexicon, 2002). Traverse section in Figure 2-1 is a system of zoning where significant elements are used for comprehensive changes from a village to a city. The changes are categorized as private, public and civic. In this range a systematic change from less density to high density; smaller buildings to larger buildings; green space to hard space; small detached buildings to large attached buildings; yards and frontages to shop frontages; narrow paths to wider sidewalks; opportunistic parking to dedicated parking; parks and greens to plazas and squares is observed (Rahnama, Roshani, Hassani, & Hossienpour, 2012).

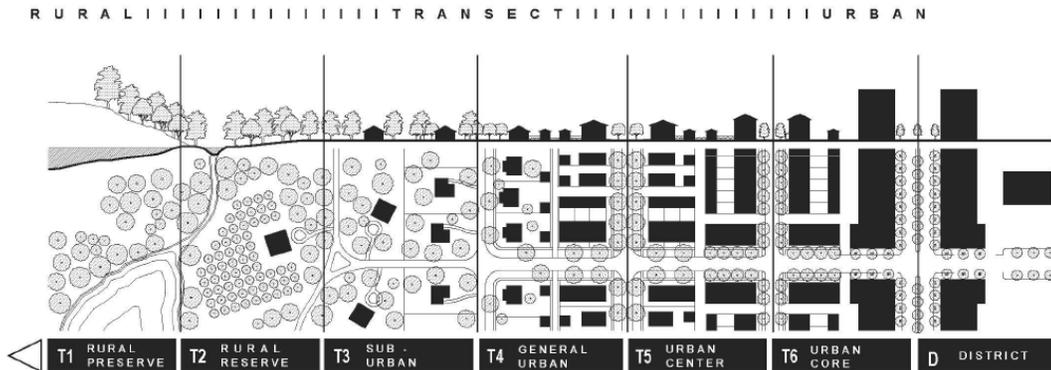


Figure 2-1 Transect for six zones from natural to human made environment (Lexicon, 2002)

Before the emergence of New Urbanism as an organized movement a number of activists, researchers and planners began to criticize the modernist planning and its implementation techniques. Social philosopher and historian Lewis Mumford criticized the post-war urban development in the North America. Jane Jacobs, the writer of *The Death and Life of Great American Cities*, emphasized some principles of New Urbanism as early as the 1960s and advocated diversity with mixed land-uses and short blocks to increase pedestrian movement at different times of the day; buildings at different ages and densities. Jacobs followed Ebenezer Howard's *The Garden City* through Lewis Mumford, Henry Wright, and a group of thinkers. She emphasized sidewalks, parks and neighborhoods in the order of the city.

The principles of urbanism can be applied to many projects, ranging from a single building to a district (New Urbanism, 2016)

Walkability

- One of the main points in New Urbanism to create livable neighboring units.
- Most activities can be planned within a 10-minute walk of home and work.

- Pedestrian friendly street design principles such as buildings close to streets, buildings with terraces, windows and doors, tree-lined streets, low speed car streets are important.
- Only pedestrian streets in some areas can be designed.

Connectivity

- To distribute motorized traffic and make walking easy connectivity can be increased by well-connected street grid network.
- A hierarchy of streets, boulevards, lanes as well as pedestrian network affects connectivity in a neighborhood.

Mixed-Use & Diversity

- Design at various scales and for various groups is important to create better places to live.
- A mix of shops, offices, houses not only within a neighborhood but also within a block and within a building.
- Diverse groups at different ages, income levels and cultures.

Mixed Housing

- A range of building types, sizes as well as prices in close proximity can be planned.

Quality Architecture & Urban Design

- A special emphasis on beauty, aesthetics, human comfort and scale at both building scale and neighborhood scale.
- Placeness.
- Design of public uses and their sites.

Traditional Neighborhood Structure

- Well-structured cities, towns, and neighborhoods with identifiable centers and edges.
- A public space at the center of a neighborhood.
- Importance of designed public open space and its quality as civic art.
- Contains a variety of land uses and building densities within 10-minute walk (Figure 2-2).

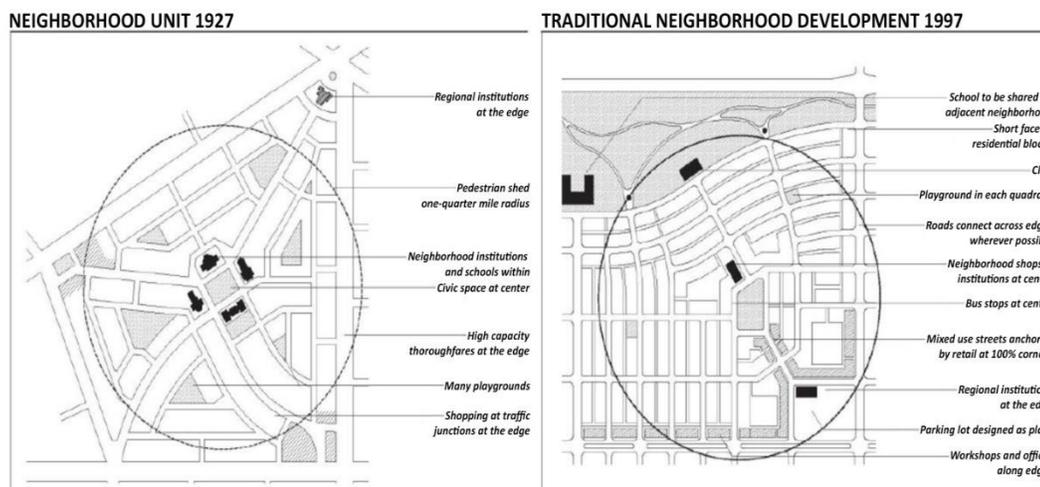


Figure 2-2 Neighboring units in 1927 and in 1997 (Lexicon, 2002)

Transect Planning

- Gradual change in densities from city center to suburbs (Figure 2-1).

Increased Density

- More buildings, houses, shops, and public services in close proximity to each other can increase walkability and provide more efficient use of land and other resources.

- Increase in densities can be applied at all scales from small towns to metropolitan areas.

Smart Transportation

- A network of high-quality railway system that connects cities, towns, and neighborhoods in a region.
- Design of alternative transportation modes such as bicycles, scooters, and walking for daily transportation can increase the quality of life and standards of living.

Sustainability

- Decrease the negative environmental impacts of development.
- Eco-friendly technologies that respect environments and natural systems values.

Energy efficiency

- To decrease the use of fuels, more walking and less driving can be promoted.
- More local energy resources and production.

Quality of Life

- For a high quality of life several New Urbanism principles can be taken and applied together.

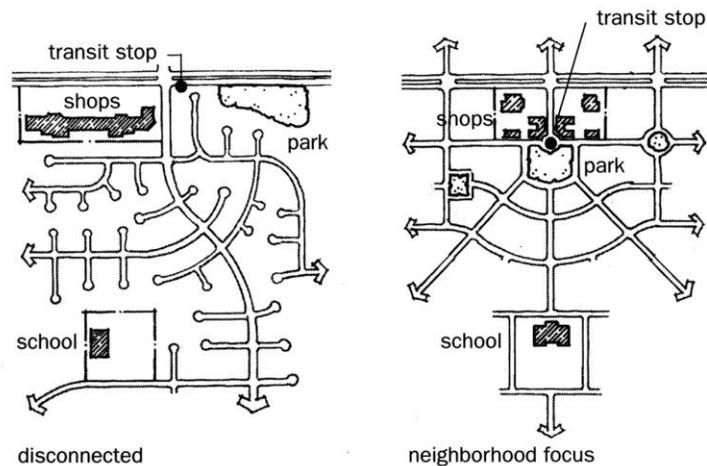


Figure 2-3 Disconnected and interconnected neighboring units
 (<https://www.webpages.uidaho.edu/larc301/lectures/tod.htm>).

Calthorpe (1993), architect and planner, another well-known member of new urbanism movement, provided urban development for a more transit-oriented metropolitan area based on New Urbanist principles and used these principles at regional scale. He redefined patterns of urban and suburban growth in the North America with diversity, walkability, public space and structure of quarters and pointed that these principles can be used in all scales of an urban area. The definition of New Urbanism was advanced by Calthorpe. He saw it as neo-traditional way to sustainable urban design and explained the basic themes of Transit Oriented Development (TOD). TOD was defined as ‘a mixed use community within an average 2,000-foot (approximately 600 m.) walking distance of a transit stop and commercial area’ (Figure 2-4). The mix uses of residential, commercial, office, green areas, and public uses in a walkable environment increase accessibility while making it convenient for residents and employees to travel by public transit, bicycle, foot, or car (Calthorpe, 1993).

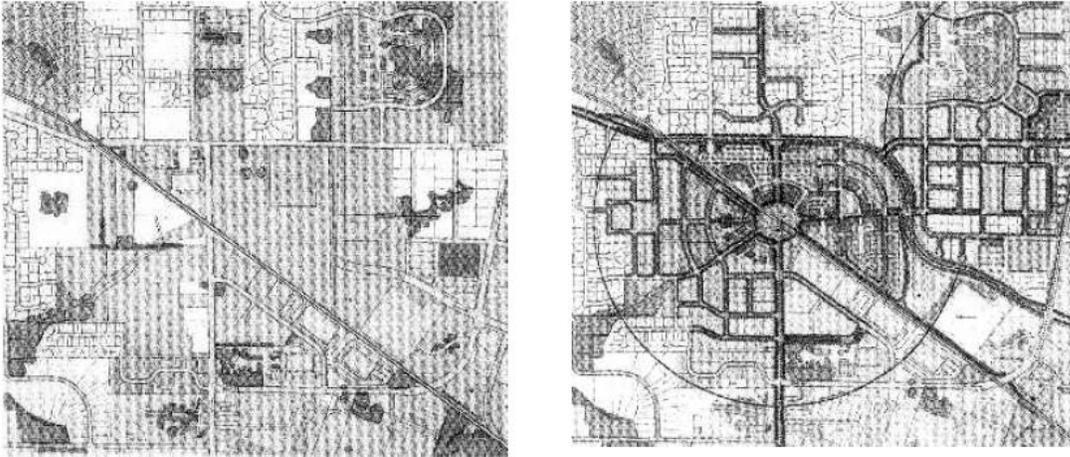


Figure 2-4 Suburban Development and TOD Development (Calthorpe Associates)

Urban design has taken a major role in planning practice for a long time, especially in developed countries. On one hand, a strong hierarchy of development plans, a set of design guidelines and conservation controls and additional design principles have been applied. On the other hand, urban design is accepted as a flexible process and design control and guidelines are continuously criticized. However, integrating different urban design approaches and extending new trends, it has been possible to develop a set of principles for higher quality of life, better places to live, work and play; better lifestyle in live-work units; less stressful and costly commuting; faster public acceptance and adoption of smart growth principles that result in cost and time savings; better systems for locality; less public investment per capita on infrastructure and utilities; less traffic congestion due to the increase in walkability and alternative uses of transport modes. Urban design has greater importance over the time.

CHAPTER 3

TRANSIT ORIENTED DEVELOPMENT

3.1 Public Transportation and Its Modes

3.1.1 Definition of Public Transport

According to American Public Transportation Association, public transportation is a passenger transport service, available for the public (APTA, 1994). A system of vehicles which offers general or special services regularly and continuously is public transportation. Its modes include trains, coaches, buses, trams and underground rapid transit, while taxi and airlines are generally not included (Farag & Lyons, 2012).

Benefits of public transportation (APTA, 2008)

- Reduce greenhouse gas emissions
- Reduce the usage of private vehicle
- Reduce congestion
- Reduce carbon dioxide emissions
- Reduce an individual's carbon footprint

3.1.2 Types of Public Transport

Bus: is a road transport vehicle designed to carry many passengers. Both public and private buses have fixed routes.

Express Commuter Bus: is a fixed route bus service with the limited stops. The service is generally in one direction during peak hours. In the morning peak, it runs from suburb to central business district and vice-versa in the evening. It should be well connected with the other modes of transportation (MP2PLANNING, 2012).

Bus Rapid Transit (BRT): Institute for Transportation & Development Policy (2015) defines BRT as high-quality bus-based transit system metro-level capacities. Fast and

frequent services with the provision of dedicated lanes are important. Bus-ways and stations are generally aligned to the center of the road.

Minibus: is a passenger-carrying vehicle. The seating capacity of a minibus ranges from 8 to 30. It has smaller capacity than a bus has.

Commuter Rail: can be defined as intercity railway freight and passenger train. It is one of the oldest passenger transit modes. It provides connection between the central business district and outer suburbs. The length of commuter rail routes is between 20 and 50 miles (around 30-80 km) (SouthEastern Wisconsin Regional Planning Commission, 1998).

Heavy Rail: is one of the transportation modes working on an electric railway with a high capacity (APTA, 1994). The system needs grade-separated surface, extensive subways and elevated structures. Its routes range between 5 and 15 miles (around 8-25 km). The distance between two stations ranges from one-half mile to two miles (around 2-3 km). Frequency of the service for the peak hour changes between 5 and 10 minutes and for the other times it extends 20 minutes (SouthEastern Wisconsin Regional Planning Commission, 1998).

High Speed Rail: is intercity passenger train which serves between metropolitan areas. High speed rail is constructed in need of the use of an upgrading current railway alignment or a new alignment with horizontal and vertical connection as well as a few grade crossings (SouthEastern Wisconsin Regional Planning Commission, 1998).

Light Rail Transit (LRT): Southeastern Wisconsin Regional Planning Commission (1998) defines as urban passenger transportation service that utilizes electrically propelled cars, or trains of cars. They are operated generally at surface level over exclusive rights-of way or streets. The length of routes changes between 5 to 15 miles (around 8-25 km) and the distance between stations ranges from ¼ mile to 1 mile (around 400-1600 meters). During the peak period, the frequency of the system is

between 5 and 10 minutes and it reaches 20 minutes for the other times. (SouthEastern Wisconsin Regional Planning Commission, 1998)

Streetcars (trams and trolleys): are local transportation. Although they are sometimes called as LRT, they differ from each other at some points. Their speed, capacity, frequency and distance between the stations are different. For example, LRT can hold 255 passengers in each vehicle while streetcars can hold between 75 and 100 passengers in each vehicle (Toronto Environmental Alliance, 2008). In addition to these differences, their vehicle size and route length are also different. Malouff (2015) created a table showing the differences between streetcars and LRT.

Factor	Light rail	Streetcar
Dedicated lanes	Often	Only sometimes
Off-street tracks	Often	Only sometimes
Bigger vehicles	Often	Only sometimes
Multi-car trains	Often	Only sometimes
Station size	Often big	Usually small
Route length	Often long	Usually short
Distance between stations	Often long	Usually short

Figure 3-1 Malouff's Table (2015)

3.2 Definition of Transit Oriented Development (TOD) and Its Benefits

The importance of the Transit Oriented Development (TOD) has increased with the rapid urban development and urban sprawl. The idea of TOD entered the terminology of urban planning in the late 1980s. Some planners and academics ardently supported this idea. They thought that TOD is a way of allaying the pervasiveness of urban sprawl and a strategy for smart growth (Calthorpe, 1993; Cervero, 1994; Bernick, 1996; Bernick & Cervero, 1997). The main purpose is to create active and more livable communities via using TOD concepts (Wann-Ming, 2015).

At the beginning, TOD was thought as an ‘academic concept’; however, this view has been changed in twenty years. Residential and commercial complexes and mixed-use projects have emerged and the number of such complexes and projects has been increasing by degrees, shaping urban development around rail stations (Dittmar & Ohland, 2004). The value of the land and the property around rail stations has become more important as much as a land or property gets closer to stations. The development of mixed-use residential or commercial area around the transport nodes relates to TOD, which causes the decrease in automobile usage (Renne, 2005).

The California Department of Transportation defines that (2003):

is moderate to higher-density development, located within an easy walk of a major transit stop, generally with a mix of residential, employment and shopping opportunities designed for pedestrians without excluding the auto. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use.

According to Transit Oriented Development Guidelines (2005);

is a walkable, mixed-use form of development typically focused within a 600m radius of a Transit Station – a LRT station or BRT stop. Higher density development is concentrated near the station to make transit convenient for more people and encourage ridership. This form of development utilizes existing infrastructure, optimizes use of the transit network and creates mobility options for transit riders and the local community.

The common definition is high-density, mixed-use development within walking distance (1/2 mile about 800 meters) of a transit station (Mixed-Income Transit-Oriented Development, 2015). The appropriate walking distance is defined as 5-10 minute walk or distance of 400 to 600 meters in the land use planning and policies. Moreover, according to New Haven-Hartford-Springfield Rail Program (2011), TOD exists within ¼ to ½ mile (about 400 to 800 meters), or within a 5-10 minute walk from a transit station (core area).

As a planning concept, TOD provides livable and sustainable urban environment by mix-use and pedestrian environment by accessibility within a walking distance of public transit stations (Hsieh & Wu, 2012).

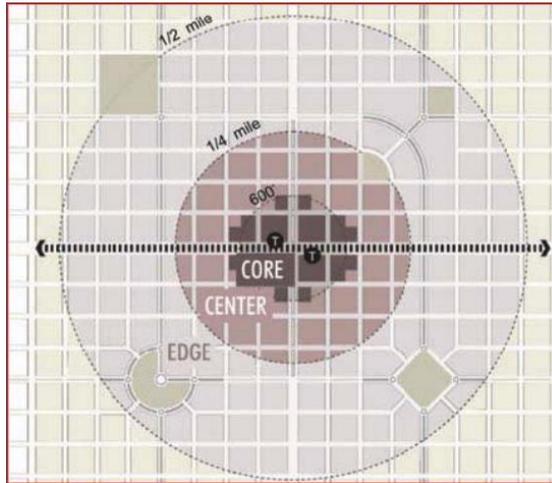


Figure 3-2 The Diagram of New Haven-Hartford-Springfield Rail Program (2011)

According to Calthorpe (1993) who developed the concept of TOD in the early 1990s; “TOD is simple: moderate and high-density housing, along with complementary public uses, jobs, retail and services, are concentrated in mixed-use developments at strategic points along the regional transit system.” (Figure 3-3 and Figure 3-4)

Calthorpe also emphasized that TOD should be within the walking distance about 2000 feet (approximately 600 meters) to transit stops and centers (Shaoming, 2005).

There are some common elements for TOD if the definitions given above are examined and summarized;

- Well-integrated public transportation
- Mixed land use
- Pedestrian friendly development
- Compact city
- Within an easy walk

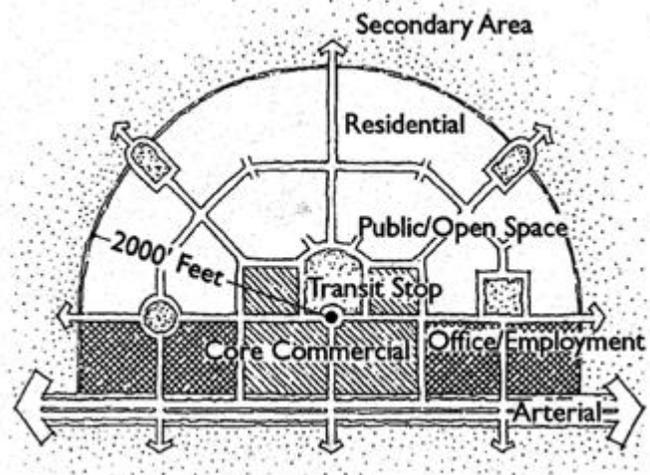
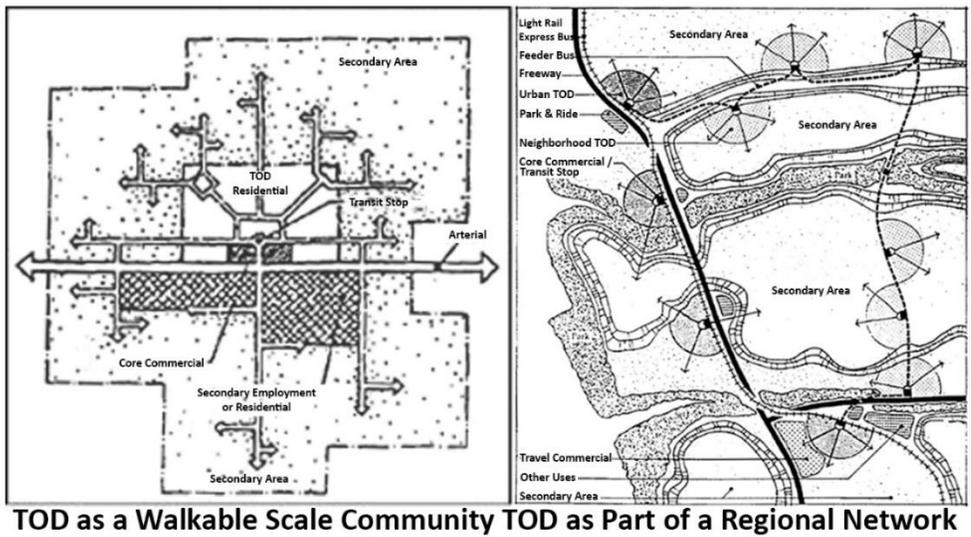


Figure 3-3 TOD Diagram of Calthorpe (1993)



TOD as a Walkable Scale Community TOD as Part of a Regional Network

Figure 3-4 Conceptual Design for TOD at local and regional scale
(Calthorpe, 1993)

3.2.1 Benefits of TOD:

Benefits of TOD can be evaluated from different perspectives. One covers the economic, environmental and social benefits of TOD. While economic benefits are listed as (1) reduced congestion, (2) increased tax incomes, and (3) reduced costs and efficient investment, social benefits are (1) increase the ability to access facilities, (2) reduce the pressure of existing centers, (3) remake the urban form, and (4) decrease the health risks. Furthermore, (1) reducing greenhouse gas emissions and (2) sustainable living are the environmental benefits of TOD. Second group examines the benefits of TOD as private or public and primary or secondary ones. According to the Report of Cooperative Research Program (2004), some benefits are public while most of them are private. Moreover, primary benefits reflect direct effects as secondary benefits are supplementary ones. Table 3-1 examines briefly the benefits of TOD in the second group. Values in parentheses show primary benefits and/or secondary benefits which are the source of the secondary benefit listed.

Table 3-1 Classification of Benefits of TOD (Cervero, et al., 2004)

Class of Benefit	Primary Recipient of Benefit	
	Public Sector	Private Sector
Primary	1. Increase ridership and fare box revenues	5. Increase land values, rents, and real-estate performance
	2. Provide joint development opportunities	6. Increase affordable-housing opportunities
	3. Revitalize neighborhoods	
	4. Economic development	
Secondary	A. Less traffic congestion and VMT- related costs, like pollution and fuel consumption (1)	G. Increase retail sales (1,2)

Table 3-1 (Continued)

	B. Increase property- and sales- tax revenues (5)	H. Increase access to labor pools (A,6)
	C. Reduce sprawl/conserv open space (1,3,6)	I. Reduce parking costs (C,2)
	D. Reduce road expenditures and other infrastructure outlays (1)	J. Increased physical activity (C,E,F)
	E. Reduce crime (3,4)	
	F. Increased social capital and public involvement (3,4)	

3.2.2 Sustainable Transport Policies, and Development and Encouragement of Non-motorized Transport

Jabareen (2006) defines sustainable transport as “transportation services that reflect the full social and environmental costs of their provision; that respect carrying capacity; and that balance the needs for mobility and safety with the needs for access, environmental quality, and neighborhood livability.”

According to European Union Council of Minister, sustainable transport system described as (Williams, 2005);

- “allows the basic access and development needs of individuals, companies and society to be met safety and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.
- is affordable, operates fairly and efficiency, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development.
- limits emissions and waste within the planet’s ability to absorb them, uses renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.”

Automobile dependency creates environmental, economic and social problems (Table 3-2). It affects human health by cost of accidents and congestion costs, and the quality of life. It also causes the loss of agricultural land and time by urban sprawl and traffic congestion.

Table 3-2 Problems of automobile dependence (Newman and Kenworthy, 1996)

Environmental	Economic	Social
<ul style="list-style-type: none"> • Oil vulnerability • Photochemical smog • Lead, benzene • High greenhouse gas contributions • Urban sprawl • Traffic problems 	<ul style="list-style-type: none"> • External costs from accidents • Pollution, health impacts • Congestion cost • High infrastructure costs in new sprawl suburbs • Loss of productive rural land • Loss of urban land to bitumen • Loss of time 	<ul style="list-style-type: none"> • Loss of street life • Loss of community • Loss of public safety • Isolation in remote suburbs • Access problems for the carless and those with disabilities

Because of these problems, sustainable transportation systems have gained importance in terms of urban areas. The current transportation trends are not fostering sustainable policies in that point. The car ownership rates have been rising faster than economic growth (Goldman & Gorham, 2006).

Land use planning has a great role in lowering the travel needs and supplying better conditions for environment-friendly transport. When the activities are located separately from each other, it is expected that travel needs are higher. To reduce the need of travel, the activities should be close to each other. It is argued that for decreasing the automobile dependency the connected street layout, mixed land use and higher densities are gain importance (Jabareen, 2006).

Through the centuries, walking had been the major transportation mode. At the beginning of the 19th century, bicycle was developed but it needed 80 years to take a

role in the transportation system with its quality and comfort. With the cars gaining a dominant role in industrialized countries in 1950s, walking and bicycle lost their importance. They used as recreational activities except in the Northern Europe, China and India (Rietveld, 2001). Car usage helped to save time and provided comfort but also it led to urban sprawl and low density urban areas (Rietveld, 2001).

3.3 Challenges and Their Solutions for TOD

In the early 20th century, urban development was sparked via the pass of railway line; however, railway lines are not the only factor in the development of an area today. Some experiential studies carried out in the 1980s and 1990s have shown that TOD could not be actualized only through many transit corridors. In fact, the effect of a rail system on urban development was not as strong as in the 1980s and 1990s (Gomez-Ibanez, 1985; Landis, Zhang, Fukuji, & Sen, 1995). Most of planners and academics have studied about the effects of railway lines on urban development. These studies examining the relations between urban development and railway lines give direction to the municipalities and developers. They have planned some complexes and projects that triggered the development around transit stations and along transit corridors. The new development has higher densities in compact forms. Nevertheless, there are still some contradictions. Loukaitou-Sideris (2010) conducted interviews and found that people had a perception related with ‘ideal’ residential neighborhoods comprised of low-density buildings and single-family houses. This view forced urban designers to challenge and build higher density structures looking less dense. Loukaitou-Sideris (2010) made an interview with an architect who mentioned about the planning in the 1960s, 1970s, and 1980s and told that developers put the structures randomly, creating disorderly building heights and messy densities. The architect and his colleagues designed blended dense building types. They used both high and low density in an order, concreating relations between each other in a balanced and coherent system.

In TOD, the other common element is creating an environment by pedestrian friendly design. Market cannot always maintain these types of land uses because of high

demand and high land and property values. To make it clear, not everyone can afford the high rents around at transit station and along a transit corridor. In addition, tax revenues that generate the budget of local government make certain land uses more attractive than pedestrian friendly or transit friendly land uses for decision-making institution. An interviewee from JSM Construction (Loukaitou-Sideris, 2010) stated that “The problem is that the types of commercial tenants we can bring are not always what the city wants. Although we would love coffee shops and pedestrian-oriented retail, we are dependent on the market and financial partners, who often prefer corporate clients.”



Figure 3-5 The concept of densities told by Polyzoides (2010)

Wealthy families who are directly independent with their couple of cars live in high rents residential units. This means they generally live near TOD areas (Arrington & Cervero, 2008). This situation creates another problem for transit agencies, planners and city council members. Wealthy families living near TOD areas use their own cars

instead of walking, biking or riding. If the ownership and usage of car in high dense residential areas do not decrease, it increases traffic congestion in these areas which create parking area problem. It is another important issue because parking area is expensive in high-density development. Planners are in a dilemma about this situation. If free parking areas near TOD are provided in large amounts, this encourages people to drive. In opposition, if there are limited parking areas near TOD, it restrains residential and commercial owners and tenants (Loukaitou-Sideris, 2010).

3.3.1 Challenges for TOD

Architects, urbanists and municipality officers have to know certain challenges and tensions for TOD. It is important to analyze the best and worst examples of TOD. These examples provide some suggestions:

Location of stations should be near people and activities. Location is the most important factor to achieve TOD. It affects new development area. It should be close to the ‘front door’ of neighborhoods, urban facilities and nodes, and hubs of activities, such as schools and parks.

Preparing pre-plan reduces time costs. It means that if municipalities prepare a pre-plan of TOD, this eases to define the advantages and goals of TOD for those regions. Moreover, they decide opportunities and risks in setting new development areas which are important for developers. Therefore, this step regulates the process of development.

Educating and including the public are important. The public should be educated extensively about the benefits of TOD. Their comments and concerns are important for the developers. The experiences of Hamburg and California supported the sharing community vision and its contribution to the planning.

Good urban design and architectural design are another important issue. Neighborhoods near transit stations should be high dense but the design of the projects should be accepted by the locals. It is important to create a smooth transition from TOD

area to the existing urban fabric. Furthermore, affordable units for all income groups promote livability of a neighborhood.

Enhancement of public or private partnership reduces the cost of TOD projects. This increases benefits in the name of public and private sides. These cost-sharing agreements and projects reduce the total development costs because they provide more efficient land uses and make empty and underutilized sites easier to fill and transform.

Establishment of a 'Council' which consolidates authority powers improves coordination among partners. Each public agency has a different priority, interest, goal and expectation. These differences restrain TOD projects in the point of defining the opportunities. Consequently, establishment of a 'Council' with the participation of all interest groups makes the preparation and implementation of TOD projects easier under the frame of vision and goals of all agencies.

The usage of pedestrian-oriented and transit-friendly development should be planned. Developers prefer larger commercial tenants (banks, furniture stores, etc.) who earn more profit. However, retail stores such as galleries, drug stores, bakeries and coffee shops create pedestrian traffic in the neighborhood. If the tenants of retail shops can afford the rents in newly developing area, it is important in TOD. Consequently, public sector should identify and plan commercial land uses and rent rates. Some incentives such as tax incentives or rent subsidies can be offered to the tenants a different store types.

Parking dilemma should be solved by applying various approaches. For example, parking space of a commercial activity should be separated from that of residential areas. TOD projects should offer different housing types and residents having an option of selecting a unit with or without parking space. To increase the effects of TOD, parking standards should be developed. In addition, shared parking is effective solution and people should be encouraged to use shared parking.

Transit system should be more attractive. This will encourage people to use transit system. Transport network and vehicles should be reliable, safe and affordable. Moreover, transit stops should be well connected with each transport line and neighborhood. In addition, some incentives should be offered to increase the use of transit system. For example, free passes from one transit system to another or reduction of cost for monthly tickets can be initiated to the passengers.

3.4 Factors of TOD

According to Cervero and Kockelman (1997), new urbanism, transit-oriented development, and traditional town planning have three common transportation objectives. First one is trip reduction that means the decrease in the number of motorized trips. Second objective is to increase the share of non-motorized trips by more foot or bicycle. Last one is to reduce travel distances and increase vehicle occupancy level by encouraging shorter trips, and using public transportation and ride sharing. These objectives are supposed to reduce the negative consequences of an automobile-oriented society such as air pollution, fossil fuel consumption, and class and social segregation (Banister & Lichfield, 1995; Dittmar, 1995). According to the urban design and planning approaches of urban design, three dimensions of the built environment¹—density, diversity, and design- should be focused in order to succeed on their objectives. These three dimensions (3Ds) of the built environment affect the demand of travel (Cervero & Kockelman, 1997). In addition, The Congress of New Urbanism (2001) supports the idea of 3Ds and argues that “Neighborhoods should be compact, pedestrian friendly, and mixed-use”. Even though the effects of density on travel demand ² have been discussed in (Levinson & Wynn, 1963) the effects of

¹ Cervero and Kockelman (1997) define built environment as “physical features of the urban landscape (i.e. alterations to the natural landscape) that collectively define the public space, which might be as modest as a sidewalk or an in-neighborhood retail shop or as large as a new town”)

² Travel demand is a demand in going from one place to another. The features of the places affect the number of trips and modes, as well as routes of travel (Levinson & Wynn, 1963).

diversity and design on travel demand have been neglected in the transportation literature. Cervero and Kockelman (1997) think that these 3Ds are related to travel demand and decided to test them by using the case studies. It was hypothesized that compact neighborhood, mixed land use, and pedestrian friendly designs decrease the number of motorized trips and encourage residents to use non-motorized trips.

Travel time differences between car and bus can affect the mode choice of households. In other words, people prefer to use transit riding in a dense, mixed-use and pedestrian friendly neighborhood because of the decrease in travel times that become closer with an automobile-use time in a neighborhood like this. There are many studies that show the importance of population density, particularly, for the travel demand, that ends at the residential area (Pushkarev & Zupan, 1977; Kenworthy & Newman, 1989; Dunphy & Fisher, Transportation, congestion, and density: new insights, 1996). However, recent studies have found the significance of other dimensions which are as effective as density in built environment. According to Holtzclaw (1990), vehicle miles traveled (VMT) per capita is two-thirds lower in a mixed-use, dense neighborhood than a suburban neighborhood. Measurement of the each dimension is difficult since each dimension includes different variables. A single variable cannot define the dimension alone but they can evaluate together. In addition to the density and diversity, accessibility and connectivity are also important factors which are analyzed into factors of TOD. According to Litman (2012), density and clustering that are different concepts increase accessibility. When housing, retail, offices and transit services locate together in a neighborhood, it provides high accessibility.

As a conclusion, compact, mixed land use and pedestrian friendly design, in other words, 3Ds on built environment influence the travel demand while decreasing VMT per capita, and inducing non-motorized trips. Dense residential neighborhoods, which are spatially accessible to retail services, are inclined to generate less motorized travels. Diversity is the second dimension having strong effect. In their studies, Frank & Pivo (1994) and Cervero (1996) mention that neighborhoods with commercial services

having mixed land use affecting the mode choices of residents for their work trips. Lastly, accessibility and connectivity affect and are affected by the other dimensions. All of these factors affect urban design and is affected by urban design elements. Cervero and Kockelman (1997) emphasize that the diversity and design have stronger influence than the density because both affect the density of neighborhoods. These factors also affect the mode choice, particularly, for non-work trips.

3.4.1 Density

‘Density’ can be simply defined as the number of units. The word ‘density’ is a complex concept. It has been used in different disciplines. There are studies which explain density by clarifying the complexity and show how to measure it. Forsyth (2003) mentioned the key points of density. According to this study:

- (1) Density is a number of units in a given area. These units can be people, dwellings, trees, and square feet of buildings.
- (2) Density is allied to the base land in its calculation.
- (3) Dwelling unit density and household size affect population density.
- (4) Some physical indicators influence the intensity of buildings.

Density can be examined into two perspectives: physical density and perceived density (Cheng, 2009).

(1) Physical density:

Cheng (2009) defines physical density as “a numerical measure of the concentration of individuals or physical structures within a given geographical unit. It is an objective, quantitative and neutral spatial indicator”. Defining the scale of geographical references is important in the measurements of density, making comparison easier. In city planning, there are two categories of physical density: people density and building density (Cheng, 2009). People density is defined as the number of people or households per a given area. On the other hand, the ratio of building structures in an area defines building density (Figure 3-6). On the other hand, physical density is not enough to increase the use of

transit system and non-motorized system. In addition to the physical density, characteristics of the streets, in other words design, are significant (Hou, et al., 2010).

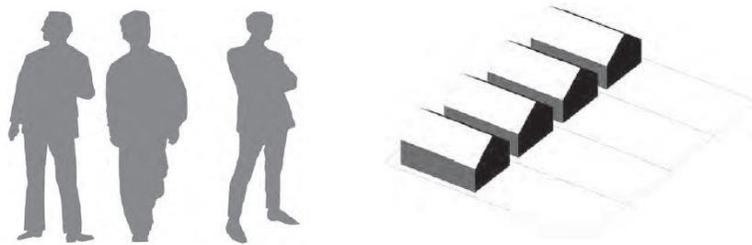


Figure 3-6 Left figure shows people density and right one shows building density (Cheng, 2009)

a. Measures of the people density

- i. Regional density: The ratio of a population to the land area of a region,
- ii. Residential density: The ratio of a population to the residential land area,
- iii. Occupancy density: The ration of the number of occupants to the floor area of an individual livable unit, such as a dwelling, office, and theatre.

b. Measures of building density

Building density has significance in shaping urban form (Cheng, 2009). Different urban forms can generate an urban environment with the same densities (Figure 3-7).

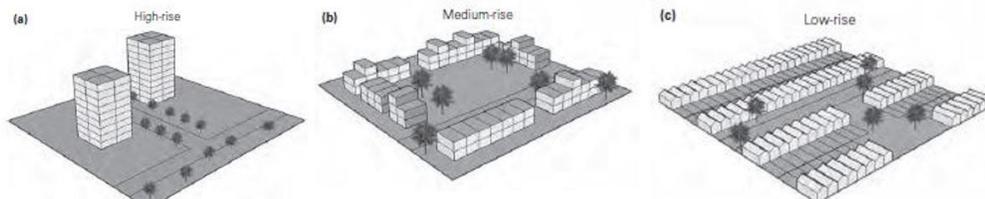


Figure 3-7 Same density in different forms: (a) high-rise buildings; (b) medium-rise buildings with courtyard form; (c) low-rise (single-storey houses) houses in parallel rows (Cheng, 2009)

Dwelling Unit (DU)/ Residential Population (RP) Densities are explained on following Table 3-3.

Table 3-3 Categories of measurement of building density

Parcel or Block Density	Parcel density	DUs or RP divided by total land or parcel area. Developers often use it.
	Block density	DUs or RP divided by block area. The measurement is easier when air photo and population census are used.
	Part block density	DUs or RP divided by a clear subset of the block area. It can be under-measure because when the boundaries are not clear, approximation method is used and sidewalks are sometimes included to the calculation.
Neighborhood	Net neighborhood residential dwelling/population density	DUs or RP divided by total residential land area. Commercial and industrial areas, shops, commercial garages, public parks, vacant land, schools, public streets and public parking lots are not include to the calculation.
	Net neighborhood residential building type density	Calculation method is similar to the method used in net neighborhood residential dwelling/population density. Only the dwellings of one type housing are counted in a neighborhood.
	Net neighborhood density	DUs or RP divided by the neighborhood area. City-wide uses are not include to the calculation.
	Gross neighborhood density	DUs or RP divided by the total neighborhood area. For this calculation, there is no exclusion.
City and larger	City density	DUs or RP divided by the whole developed area of the city or town.
	Metropolitan density	DUs or RP divided by total land area. This calculation includes undeveloped areas.

Table 3-3 (Continued)

	Net residential density at city or metropolitan level	DUs or RP divided by residential land at a city or larger level.
Built area intensity measures at parcel or block level	Floor area ratio (Plot ratio)	Built floor area on all floors divided by the parcel area. In other words, the ratio of gross floor area to its site area that is the total lot area of the development is defined as plot ratio.
	Building site coverage	Area of ground floor footprint of buildings divided by the parcel area.
	Building block coverage	Area of ground floor footprints of buildings divided by the block area.
	Impervious surface parcel coverage	Area of ground floor building footprint plus paved parking lots, drives, sidewalks, paths, decks and other buildings divided by site or parcel area.
	Impervious surface block coverage	Calculation method is similar to the method used in impervious surface parcel coverage but block area is calculated instead of parcel area.
	Front parcel setback in feet for parcel	The distance from the front façade of the building to the front property line.
	Front curb setback in feet	The setback of each building from the curb averaged by building over a block.
	Side to side distance between buildings	Measured in feet and averaged across a block.
	Back to back distance between buildings	Measured in feet and averaged across a block.

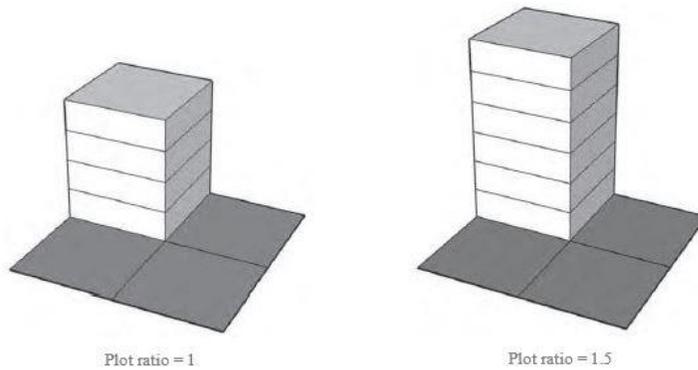


Figure 3-8 Different plot ratio (Cheng, 2009)

Forsyth (2003) summarized different measurement types of density and intensity as:

Table 3-4 Measurement types of density and intensity

Relatively difficult to calculate due to exclusions	Easily calculated from field observations and measurements from aerial photos supplemented with web-accessible census data	Easily calculated using GIS parcel level database, including assessors data and/or census data and TIGER line files
<ul style="list-style-type: none"> • Net Neighborhood Density 	<ul style="list-style-type: none"> • Block Density 	<ul style="list-style-type: none"> • Parcel Density
	<ul style="list-style-type: none"> • Part Block Density (parcel approximation) 	<ul style="list-style-type: none"> • Net Neighborhood Residential Dwelling/Population Density
	<ul style="list-style-type: none"> • Gross Neighborhood Density 	<ul style="list-style-type: none"> • Net Neighborhood Residential Building Type Density
	<ul style="list-style-type: none"> • Building Block Coverage 	<ul style="list-style-type: none"> • City Density

Table 3-4 (Continued)

	<ul style="list-style-type: none"> • Impervious Surface Block Coverage 	<ul style="list-style-type: none"> • Metropolitan Density (MD)
	<ul style="list-style-type: none"> • Building Height 	<ul style="list-style-type: none"> • Residential Density at City or Metropolitan Scale
	<ul style="list-style-type: none"> • Front Curb Setback 	<ul style="list-style-type: none"> • Floor Area Ratio
		<ul style="list-style-type: none"> • Building Site Coverage
		<ul style="list-style-type: none"> • Impervious Surface Parcel Coverage
		<ul style="list-style-type: none"> • Front Parcel Setback
		<ul style="list-style-type: none"> • Side to side distance
<ul style="list-style-type: none"> • Back to back distance 		

(2) Perceived density:

The definition of perceived density is question (Rapoport, 1984). Perceived density is not related to actual density. Rapoport (1975) defines perceived density as an individual perception and prediction about the number of people in a certain area. Not only spatial characteristics also interaction levels between individuals and the environment are important to define perceived density. In other words, relationships between individual and space and between individuals in the space are concerned in perceived density. Perceived density is subjective because it is based on the personal intelligence. It changes by urban design, such as the size of buildings, space between buildings, building façades, and visual access to open and green spaces (Cooper Marcus & Sarkassian, 1988). While Bonnes et al (1991) attract the attention into the importance of street width, building height, and balance between built-up and vacant spaces on the

perception of density, Forsyth (2003) points out landscaping, aesthetics, noise level and building types in perceived density.

People can use the word ‘**crowding**’ instead of ‘**density**’. However, crowding and density are not the same thing. Crowding means the psychological stress related to negative aspects of density (Churchman, 1999). Forsyth (2003) explains the differences between crowding and density with these sentences: “It is possible to live at very high density in a spacious apartment with no crowding, and conversely it is possible to live in a detached farm house that is crowded in terms of having many people per room.”

3.4.1.1 Effects of density on the city:

Although they have the disadvantages, especially with respect to social sustainability, urban policies have supported the development of high residential density in recent years (Bramley; et al., (2009)).

Croucher; et al. (2012) mentions about the positive and negative effects of high density development that are shown in Table 3-5.

Table 3-5 Positive and negative effects of high density (Croucher, Wallace, & Duffy, 2012)

Positive impacts of high density development	Negative impacts or high density development
Increase active travel and therefore physical activity.	Reduce urban greenspace and play space.
Increase ease of access to facilities and services.	High-rise developments linked to poor mental health.
Increase social interaction.	Increased noise increases stress and conflict between neighborhoods.
Increase possibility for mix of communities	

The built environment is affected by the density of population and employment (Chow, 2014). There is a strong relationships between the density and urban characteristics.

Integration of them provides more improved social integration, low of travel time and more livable environments.

Within the context of density, urban compactness can be shaped horizontally and vertically. While low density has large amount of area which is needed and provided by open spaces and roads, high density does not need large area because different activities gather in that area. In addition, while low density increases walking distance, high density has a reverse situation. Density also affects the choice of mode. People prefer to use public transit systems in medium or high density area.

On the other hand, Stead and Banister (2001) state how high density supports the sustainability. According to this;

- High density needs less area, therefore it provides reduction of travel and efficient usage of energy.
- There are more accessible transport modes.
- It provides more local employment.
- It provides compactness because of the concentration of the facilities which reduce the usage of automobile.
- The area provides walking and cycling.

Compact neighborhoods decrease vehicle trips and increase non-motorized trips since origins and destinations are close to each other in a compact neighborhood. This encourages people to walk and cycle. Furthermore, compact neighborhoods have less parking area, more developed transit system and mixes of land uses. All these factors decrease personal car usage (Cervero & Kockelman, 1997). In other words, urban density and car usage have an inverse relationship (Kenworthy & Newman, 1989). For example, if the density is high, car usage is less at the city center. This explains the inverse relationship. However, well-designed public transport has a role in the point of supporting this relationship.

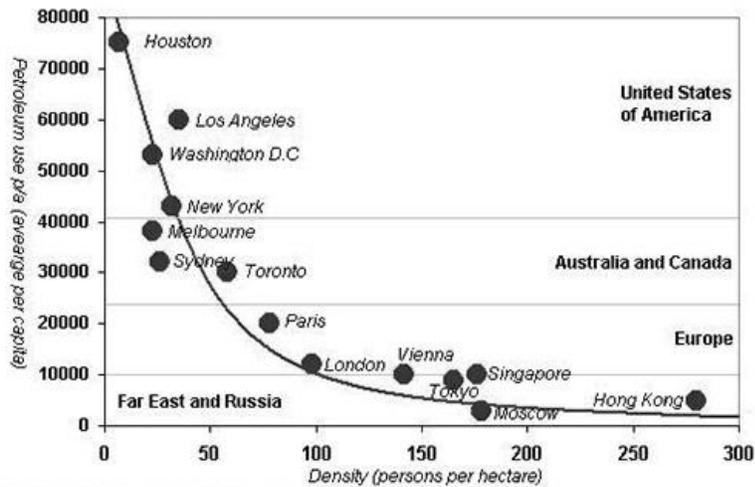


Figure 3-9 Relationship between density and petroleum usage (Kenworthy & Newman, 1989)

Residential density is important to achieve sustainability for the governments. It can be calculated with two methods: (1) the number of dwellings per hectare or (2) the number of people per hectare. Residential density can be analyzed into three categories. First, higher residential density area which is situated near city center should be developed along public transport routes and they should be more accessible. Second, medium residential density areas located near high amenity zones should be near activity center and close to public transport routes. Last, lower residential density area is located at the fringes and it is called suburban area. (Healthy Spaces & Places, 2009). High residential densities decrease the possibility of urban and suburban sprawl. In addition, it is thought that high residential densities increase the interaction between residents and make people more social (Croucher, Wallace, & Duffy, 2012). High residential densities also cause an increase of mixed land use (Bramley, Dempsey, Power, Brown, & Watkins, 2009). Therefore, high densities allow people to access retail facilities and their work by walking, cycling or riding. It is thought that lower income households, limited parking lots, more intensive bus services, and mixed land uses are correlated with *density* (Cervero & Kockelman, 1997). When the people density is high, the

efficiency of public transportation increases if only the transportation system is well planned. High density brings the concentration of people and creates opportunities for walking and cycling. Therefore, it reduces the traffic congestion, number of car trips, and travel distance per trip. According to Litman (2012), density and clustering which are different concepts increase accessibility. When housing, retail, offices and transit services locate together in a neighborhood, it provides high accessibility.

3.4.2 Land Use and Diversity

The term of the ‘diversity’ can be used in different meanings in urban planning and design literature. A various physical design, mix land use, large public spaces are some of these meanings (Fainstein, 2005). While urban designers consider it as mixing in building types, planners consider mixed uses or class and racial heterogeneity. In addition, sociologists and cultural analysts use this term as the same meaning with planners. Adelaide City Council (2011) defines diversity as “Development which comprises a mixture of two or more land uses, either comprises within a single building (horizontally or vertically) or multiple buildings of different uses within a distinct development site.”

Jane Jacobs (1961) who introduces the concept of mixed use emphasized diversity as a fundamental factor for livability, economic growth and attractiveness of cities. Since 1960s, diversity has gained ultimate importance on retail facilities and marketing (Teller & Reutterer, 2008). Jane Jacobs (1961) encourage the economic and social diversity:

It becomes the heart of my argument. This ubiquitous principle is the need of cities for a most intricate and close-grained diversity of uses that give each other constant mutual support, both economically and socially. The components of this diversity can differ enormously, but they must supplement each other in certain concrete ways.

In her study, it is argued that diversity makes cities more attractive which is also the source of the economic productivity. Thinking the diversity in physical, economic and

social manners, she is more concerned with the economic diversity. On the other hand, Young (1990) gives more importance to social diversity rather than economic diversity.

In her book, she mentions the diversity as “What makes urban spaces interesting, draws people out in public to them, gives people pleasure and excitement, is the diversity of activities they support.”

City planners use the diversity as a new guiding principle. The level of diversity is the most important criteria to evaluate urban form. Diversity attracts human capital and encourages innovation. Moreover, it provides fairness and equal access to different social groups. Diversity has several meanings in urban morphology and design is creating two different problems. The first problem is that the definition of diversity is not absolute enough to categorize the meaning. The second one is that the measurement of diversity is very difficult due to the lack of suitable analytical tools (Serdari Sayyar & Marcus, 2011). Consequently, the terms and forms should be analyzed to understand diversity at first and then the indices for measurement should be understood.

3.4.2.1 Forms of Diversity

Diversity can be obtained in several forms. The most basic one is to create different building types and a mix of high and low rise structures. The new residential development of Amsterdam harbor can be given as an example of diversity. There are both apartments and townhouses. The townhouses disarrange the uniformity of traditional Amsterdam design patterns. Although architectural homogeneity is seen on the streets in Amsterdam, offices, residences, and the retail services appear side by side in an order (Fainstein, 2005). Besides building types, social diversity is another issue of mixed land uses. In Amsterdam example, there is social diversity where architectural homogeneity dominates since people from different social groups can afford the rents by the support of Dutch state according to the income levels of the households (Fainstein, 2005). Diversity also increases the appeal of the urban environment because it promotes creativity and tolerance.

3.4.2.1.1 Mix Land Use:

Mixed land use sometimes has the same meaning with the diversity of land uses. It is one of the effective factors in the decrease of non-motorized and public transport trips (Bordoloi, Mote, Sarkar, & Mallikarjuna, 2013). Mixed land use can be defined as the heterogeneity of land uses in a qualified area (Croucher, Wallace, & Duffy, 2012). The mixing of residential and commercial uses is supported by the Smart Growth Network³ (2006).

According to Healthy Space & Place (2009), mixed land use, which includes residential, commercial, institutional, industrial, recreational, and agricultural uses (Croucher, Wallace, & Duffy, 2012), supports sustainable transport modes such as public transport, bike and foot (Figure 3-10). In order to create economic opportunities and enhance perceived safety and security, mixed land use development which increases the number of people on the streets and in public spaces should be designed.

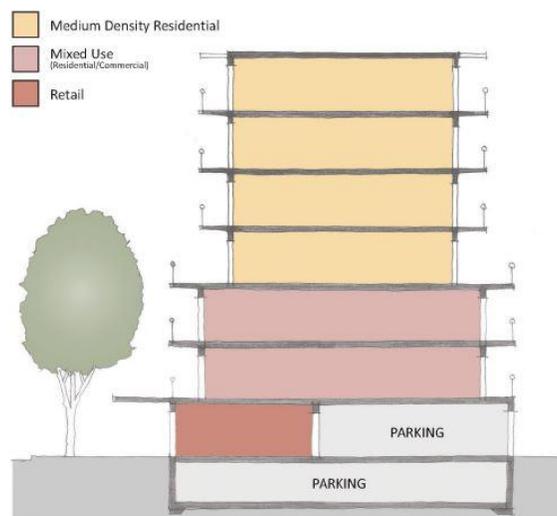


Figure 3-10 Mix land use (Healthy Spaces & Places (2009) and Adelaide City Council)

³ The Smart Growth Network was established under the patronage of the U.S. Environmental Protection Agency

Mixed land use buildings with housing, retail, commercial and amenities also encourage social interaction between people while creating opportunities for local employment. If the local employment increases, the number of travel, trip length and time reduce (Evans, 2005). Cervero and Radisch (1996) find that the ratio of mixed land use in a given area is a good indicator showing the choice of travel mode. In addition, Cervero and Kockelman (1997) use two indices which are important to explain the vehicle-miles travelled (VMT) and the non-motorized travel to measure the effect of mixed land use. Moreover, Tsai et al (2012) examine the influence of the trip length, non-motorized mode choice and transit mode choice as the travel parameters (Bordoloi, Mote, Sarkar, & Mallikarjuna, 2013). A neighborhood should include working places, educational and recreational areas, retail opportunities as well as regional transport connections within comfortable walking and cycling distances. The high density is important for the diversity because the land uses mentioned above cannot survive financially without the high population. Furthermore, walkability, travel costs and fuel use (Kenworthy & Newman, 1989) are affected by the mixed land use. Shopping and retail activities which are placing on the route of workers from transit stop to their homes encourage people to use transit commuting (Cervero & Kockelman, 1997). Compact city involves mixed-use which also refers to diversity. It can be analyzed into four groups (Evans & Foord, 2007):

- Social mix: income, housing tenure, demography, visitors, lifestyles
- Economic mix: activity, industry, scales (micro-large), consumption-production
- Physical land use mix: planning use-class, vertical and horizontal, amenity/open space
- Temporal mix: 24-hour economy, shared use of premises/space.

Rowley (1996) defines the important variables in mixed-use (

Table 3-6). In addition, he lists heterogeneous practices and the importance of local/specific conditions.

Table 3-6 Variables in mixed-use (Evans & Foord, 2007)

Variables	Contents
Location types, uses and activities	Nature of users, occupiers, compatibility, comings & goings, mix and balance of primary and other uses, synergy
Intensity/density, grain of development, permeability	Street layout, ease of movement, footfall along routes
Character of surrounding development	Age of area and buildings, capacity to respond and accommodate to change, range of design considerations, size of units, within & between buildings/public spaces-vertically and horizontally, visibility and legibility of uses
Market	Local/ regional property and development economics, organizational flexibility
Social-cultural mix	History, settlement, lifestyle trends/demands, tenure
Planning and urban policy	Regeneration, design guidance, licensing

3.4.2.1.2 Forms of Mixed-Use Development:

‘Vertical’ mixed use is in a single building. It includes accommodation, offices and other uses in one building and the usages are layered floor by floor. ‘Horizontal’ mixed use is a group of adjacent buildings on a single site. On the contrary to ‘vertical’ mixed use, each building has specific purpose (Figure 3-11).

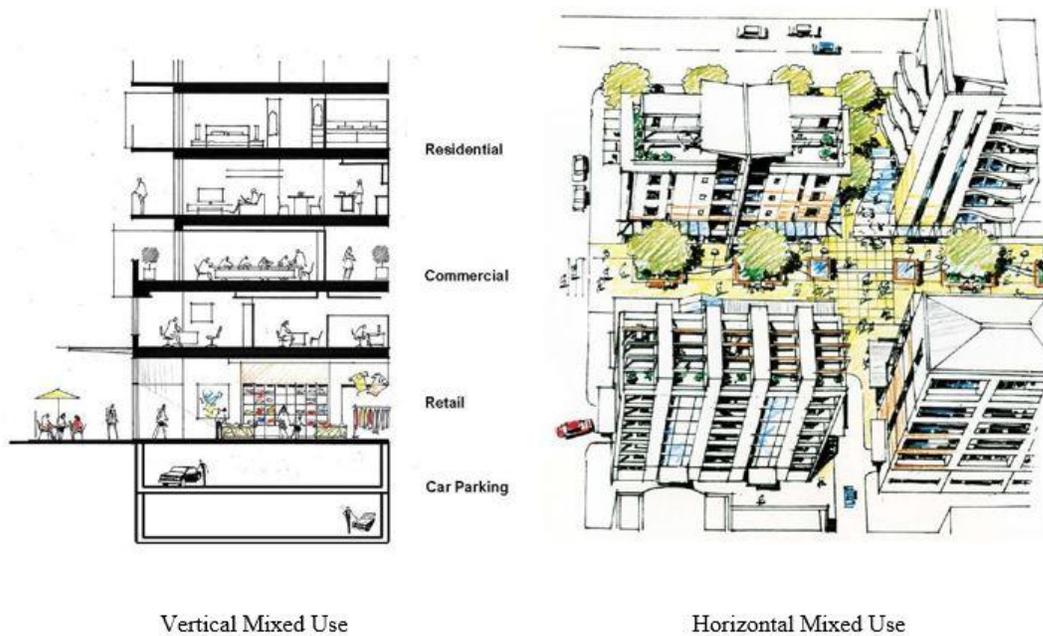


Figure 3-11 Forms of mixed use development (Adelaide City Council, 2011)

3.4.2.1.3 Measurement of Diversity

To evaluate the diversity, two important indices, that are categorization and scale should be focused. *Categorization* is one of the important factors for analyzing the diversity in urban space (Harvey, 1969; Wilson, 2000). For example, if the categorization is based on the residential and working population, the diversity index will be different from the economic diversity. If the categorization is based on the variety of offered goods, the index will give another type of diversity. Therefore, diversity can be low and high at the same time depending on the classification. The observed patterns of diversity and their interpretation are impressed by the *scale of diversity*. In other words, an area which is seen homogeneous on one scale can be heterogeneous on another scale.

Choi and Sayyar (2012) divide the scale into 'relative scales' and 'absolute scales'. While Choi and Sayyar explain that the study of the objects and their relationships or the processes and their relationships as *relative scales*, Gibson, et al. (1999) define it as "a transformation of an absolute scale to one that describes the functional relationship of one object or process to another". On the other hand, the study of independent objects or processes is defined as absolute scales. Gibson et al. (1999) define it as "The distance, time, or quantity measured on an objectively calibrated measurement device."

Song and Knaap (2004) state that there are two measures for land use mix: the actual mix of non-residential land uses in the neighborhood and the mix of zoned non-residential land uses. For the first measure which provides a ratio indicating the land use mix, acres of commercial, industrial and public land uses in the neighborhood are divided by the number of housing units. For the second measure, acres of land zoned for central commercial, general commercial, neighborhood commercial, and office commercial, industrial and mixed land uses are divided by the number of housing units. The higher ratio shows the grater mix land use (Song & Knaap, Measuring urban form: Is Portland winning the war on sprawl?, 2004).

Different indices are used for measuring the mixed land uses. The researcher needs to know number of land use dimensions of interest and the approximate scale to apply appropriate measure index:

Balance Index: Existence of mixed land use an appropriate geography

Entropy Index: Balance among the different land uses in equal percentages

Atkinson Index: Measurability of the land use types

Clustering Index: Analysis of the land use patterns at the district scale

Dissimilarity Index: Testing the district sizes at different scale

Exposure Index: Analysis of different size.

3.4.2.1.4 Benefits of Diversity

The advantages of mixed-use development or diversity which encompass economic, social and environmental benefits can be listed as Figure 3-12:



Figure 3-12 Advantages of Mixed-use Developments
(Evans & Foord, 2007)

The **benefits** can be analyzed into three basic categories: transportation, public health, and urban economics (Song, Merlin, & Rodriguez, 2013). Being closer to a variety of origins and destinations is one view of *transportation*. This closeness provides the uses of non-motorized modes and/or shorter travel distance. For the view of *public health*, it can be said that the variety of interesting destinations near residential areas encourages people to use active travel modes. Finally, mixed land use promotes to increase land values and encourage high-density development according to *urban economics* (Song & Knaap, 2004). Although there are several studies which are declaratory about the relationships between automobile usages and mixed land uses, Ewing et al (2003) find no relationship between them while others find a negative

relationship (Cervero, 1996; Hess & Ong, 2002). In spite of opposite views and findings, mixed land use has several benefits. It not only increases the viability of transportation modes but also helps to build a sense of place. In addition to these, there are some benefits for the developer, public and the environment.

Benefits for the developer:

- An adaptable building that contains flexibility to change uses,
- Usage of environmentally efficient materials and designs,
- The opportunity to continuation residential and commercial/retail tenancies because residing and working in the same building – mixed-use building- create efficiency.

Benefits for public:

- Increase the choice of housing, employment, business and investment,
- Accessibility to activities in one location with the help of mixed land use,
- Interesting and vigorous streets created by diversification of activities,
- More efficient use of public infrastructure.

Benefits for the environment:

- Reduction to the vehicle dependency
- Opportunity to use “green” technologies

3.4.3 Accessibility and Connectivity

Connectivity of the street network increase the use of transit mode and high connectivity provides high level of accessibility. There are different concepts such as ‘great streets’, ‘livable streets’ and ‘complete streets’ in the US. These concepts adapt both non-motorized and motorized modes for the social life and active living (Schiller et.al, 2010). It is a common belief that transit stations affect people because of having different activities around the station.

The presence of sidewalks, pedestrian ways and their continuity affect the connectivity. In addition, while location of the transit station becomes a key factor for affecting

accessibility, the second key factor is the distance from and to the station. Furthermore, the placing and shaping of blocks affect the length of trips. Within this context, grid and small blocks provide shorter trip length which means more efficient trip.

Many researches evaluate the effect of built environment on the travel choice by concentrating on road network design, street connectivity, block size and density. A grid network which can be defined as the simplest street pattern was the most preferred model in neo-traditional neighborhood design. It increases walkability and provides street connectivity. It is possible to reduce car trips by between 10-40% with interconnected streets. According to the researches of RTD Transit Access Committee (2009), people prefer walking on completed sidewalk networks to station.

Figure 3-13 shows the variations of grid system which provides high connectivity and attractiveness for all users (Jacobs J. , 1961).

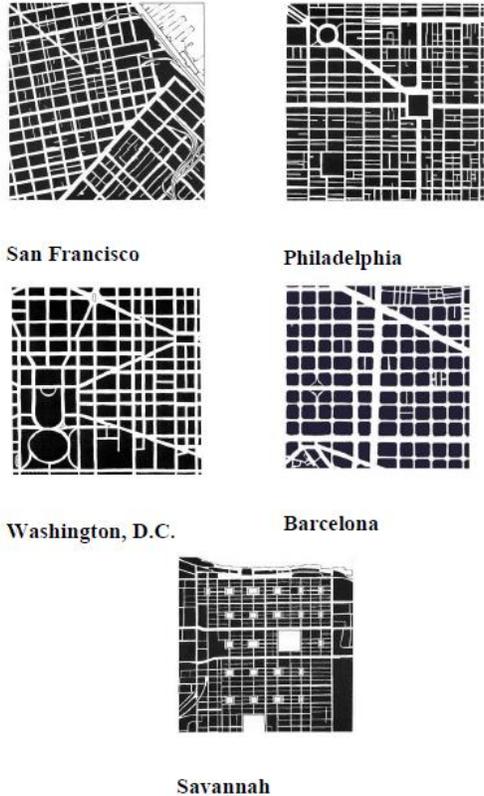


Figure 3-13 The variations of street connectivity for grid system (Jacobs J. , 1961)

Litman (2012) shows the accessibility on grid system with an example. Short and connected roads and multiple routes help to create direct connection between destinations which is shown in Figure 3-14.

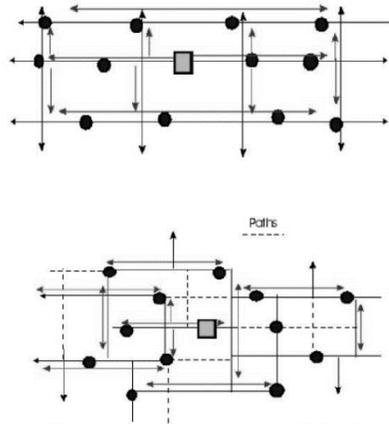


Figure 3-14 Grid road network

Destinations which are located together, a connected loop and location at the crossroads, and direct travel between nodes are the examples for increased accessibility. On the other hand, circuitous routes, cul-de-sacs and dead-end roads decrease walkability. Therefore, when the intersections of the roads increase, connectivity and accessibility increase.

Pedestrian routes are important for success of transit modes because every trip starts and ends with walking. For this reason, pedestrian routes should be short, continuous, direct and convenient. Numbers of crossing, stairs and grade are important to increase walkability. In addition, transit station should have integration with other transport modes in walking distance.

According to study of Bertolini (2005) which is named as *Node-Place Theory*, the number of nodes and intersections, the distance between points of access into the

neighborhood, the number and lengths of blocks, and the lengths of cul-de-sacs are measured for connectivity.

According to study of Litman (2012), *connectivity index* which is used to evaluate the network connection of destinations is found by dividing the number of roadway links by the number of roadway nodes. High index represents increased choice of travel and more direct connections. Litman (2012) states that the different people and groups have different needs of accessibility. Table 3-7 shows that the definitions of the tendency of groups with rating from 3 (most important) to 0 (unimportant) with regard to Litman's study.

Table 3-7 Tendency of groups with importance of transportation modes

Groups	Walking	Cycling	Driving	Public Transit	Taxi	Air Travel
Adult commuters	2	1	3	2	1	1
Business travelers	2	0	3	2	3	3
College students	3	3	2	2	0	1
Tourists	3	2	3	2	2	3
Low-income people	3	2	2	3	2	0
Children	3	3	2	1	0	1
People with disabilities	3	2	1	3	2	2
Freight delivery	0	1	3	0	1	1

Song and Knaap (2004) calculate connectivity with five different approaches:

- **Intersection_Connectivity:** It is calculated by dividing the number of street intersections by sum of the number of intersections and the number of cul-de-sacs. The higher ratio shows the greater internal connectivity.
- **Blocks_Perimeter:** It is the median perimeter of blocks. The smaller perimeter shows the greater internal connectivity.
- **Blocks:** It is calculated by dividing the number of blocks by number of housing units. The fewer blocks show the greater internal connectivity.
- **Length_cul-de-sac:** It is the median length of cul-de-sacs. The shorter cul-de-sacs show the greater internal connectivity.
- **Ext_connectivity:** It is the median distance between access points in feet. The shorter distance shows the greater external connectivity.

CHAPTER 4

TOD DESIGN, URBAN DESIGN AND TRAM DESIGN

4.1 TOD Design

In the past few decades, TOD has become known as a popular and powerful planning concept all over the world. TOD is one of the tools for integrating public transportation investments and land use practices to create walkable and diverse neighborhood in both city center and suburban.

TOD which provides places for people to live, work, shop and relax influences many people who have different standards and different reasons for using the same space. TOD designers need to pay regard these concerns without sacrificing economic efficiency or conflict with larger community goals. Urban design is a tool for achieving the balance between built environment and the needs of people (Jacobson & Forsyth, 2008). While policy design is interested with frequency of transit service, pricing, equity, development mechanism and regulation, regional scale planning concerns with other policy issues (Calthorpe & Fulton, 2001). However, urban design concerns with real-world constraints of space, time and money. Jacobson and Forsyth (2008) analyze urban design into twelve dimensions clustered under three main categories: processes, places and facilities (Table 4-1).

Table 4-1 Examples of urban design dimensions of TOD (Jacobson & Forsyth, 2008)

Processes	Time
	Engagement with public
	Programming
	Maintenance
Places	Scale
	Public spaces for human use

Table 4-1 (Continued)

	Safety
	Variety and complexity
	Connections
Facilities	Pedestrian/non-motorized orientation
	Transit in urban pattern
	Car movement and parking

Design issues in the implementation of TOD projects should be considered by transit planners, planning officials, real estate developers and community organizers. Solutions which are provided by urban design can change in time and some of them can work better than others. Because of this, lessons are derived from the past experiences (Jacobson & Forsyth, 2008).

Jacobson and Forsyth (2008) analyze the seven countries under six methods (Table 4-2). They include quantitative and qualitative indicators, existing data and some urban design characteristics such as aesthetics, sense of place and perception.

Table 4-2 Methods for analyzing area (Jacobson & Forsyth, 2008)

Methods	Explanation
An urban design score sheet	<ul style="list-style-type: none"> - Walkable, mixed residential and commercial environments - Imageability, enclosure, human scale, transparency, complexity
An urban design inventory	<ul style="list-style-type: none"> - Ease of movement, pleasurability, attractiveness, perceived safety
Design workshops	<ul style="list-style-type: none"> - Evaluation technique - Characters of design, strengths and weakness, memorable aspects
Community representative workshops	<ul style="list-style-type: none"> - Evaluation technique - Allowing to compare the groups of experts and community representatives
GIS-based analysis	<ul style="list-style-type: none"> - Street networks, level of mixed uses, figure-ground relationship

Table 4-2 (Continued)

	and intersection densities (measure of street connections)
Photographic visual assessment	- Compare and contrast within color, form, line, texture, scale and spatial.

TOD design guidelines:

- Downtowns should be dominated by office buildings.
- Parking lots should not be so far away from transit station.
- Activities increase the use, safety and sense of place.
- Pedestrian and cycling facilities are important keep alive around transit stations.
- Areas should be designed to people moving at walking speed.
- Areas should be provided with human scale details such as street furniture and plantings.
- Street furniture provides public space for people to sit and talk.
- Public art makes place special by providing visual clue.
- Public space should be appropriate for different users and activities at different times.
- Personal safety is crucial for the success of public space.
- Eye-level streets increase safety.
- Lighting is important within safety context to increase visibility.
- There should be provided an access control between public places.
- There should be adequate sight lines to provide visibility.
- There should be avoided tunnels and narrow paths to keep away people form entrapment spots and isolated areas.
- Connection between great places is important. While creating great places, the connection should be provided.
- Streets and blocks should provide multiple options for pedestrians moving from place to place.
- Parking area should be designed with maximum efficiency and minimum danger for both pedestrians and space.
- Traffic should be separated from pedestrians with buffers.
- The look of street should be improved by using landscape elements such as trees, flower boxes and strips of grass.
- Restaurants on sidewalks arouse a feeling of safety and vitality.

- Pedestrian area and driver area should be distinguished from each other.
- Providing comfortable transit is important to encourage people to use transit services.
- Some amenities such as places to sit, public telephones and shelter should be provided for pedestrians.
- Some traffic calming strategies such as narrow roads and speed bumps should be implemented for increasing the safety of pedestrians.

4.2 Urban Design

Urban design is a discipline which creates places for the people. Urban design is process of designing and organizing spaces and it deals with the functions of places and their systematics, and includes community safety. Moreover, relationship between people and places, urban form and built fabric are matters of the urban design (Commission for Architecture and the Built Environment, 2000). Urban design was emphasized in 1998 when the Urban Design Alliance was established by five professional institutes. The alliance combines town planners, landscape architects, surveyors, architects and civil engineers (Commission for Architecture and the Built Environment, 2000). Even though they are from different disciplines, they have a common purpose in sharing cities, towns and villages and decide to work together for a better urban design.

Urban design encourages walking by increasing accessibility and connectivity (Croucher, Wallace, & Duffy, 2012). To encourage walking from one point to transit station or vice versa, the key principles that address and ensure good urban design should be set out. These include development that promotes mixed land uses – residential, leisure, work, retail services- and safe and connected sidewalks with street light, safe pathways, and developed landscape (Heath, et al., 2006). Good urban design helps to create successful economic development and social life. Spirited places with unique character, safe and accessible streets and public spaces are promoted with urban design. Common characteristics of successful streets, spaces, towns and cities produce objectives of good urban design. The objectives, shown Table 4-3, complement and

support each other. Eventhough these objectives are abstract, the form of buildings, structures and spaces are concrete in urban design. The built environment and land use patterns affect trip durations and mode choices.

Table 4-3 Objectives of Urban Design (Adapted from Commission for Architecture and the Built Environment, 2000)

CHARACTER	<i>A place with its own identity</i>	To promote character in townscape and landscape by responding to and reinforcing locally distinctive patterns of development, landscape and culture.
CONTINUITY AND ENCLOSURE	<i>A place where public and private spaces are clearly distinguished</i>	To promote the continuity of street frontages and the enclosure of space by development which clearly defines private and public areas.
QUALITY OF THE PUBLIC REALM	<i>A place with attractive and successful outdoor areas</i>	To promote public spaces and routes that are attractive, safe, uncluttered and work effectively for all in society, including disabled and elderly people.
EASE OF MOVEMENT	<i>A place that is easy to get to and move through</i>	To promote accessibility and local permeability by making places that connect with each other and are easy to move through, putting people before traffic and integrating land uses and transport.
LEGIBILITY	<i>A place that has a clear image and is easy to understand</i>	To promote legibility through development that provides recognizable routes, intersections and landmarks to help people find their way around.

Table 4-3 (Continued)

ADAPTABILITY	<i>A place that can change easily</i>	To promote adaptability through development that can respond to changing social, technological and economic conditions.
DIVERSITY	<i>A place with variety and choice</i>	To promote diversity and choice through a mix of compatible developments and uses that work together to create viable places that respond to local needs.

Decrease in automobile travels causes lower greenhouse gas emission, and lower per capita energy use (James Taylor Chair in Landscape & Liveable Environments, 2001). *Design* of neighborhoods has an influence on the travel demand. For example, shade of trees along the sidewalks and parking area back to the stores affect travel demand. In addition, good design makes places more accessible by walking (Cervero & Kockelman, 1997). If the stores are easily accessible within the neighborhood, people prefer to walk or cycling rather than driving (Handy, 1993; Cervero & Radish, 1996). Some regulations about the design help to reduce car usage. For example, paid parking within the center of neighborhood induces people to walk.

Defining the differences between conventional suburban development and compact development patterns is essential to understand the effects of land use patterns on travel behavior. An integrated street system and reduction in the hierarchy of streets qualify compact development, which is also called as traditional development. To contribute this development, street system, travel speeds, pedestrian paths and parking system should be designed in parallel to the pattern land use.

It is very difficult to measure design criteria. Design has different scales, i.e. regional/city scale, local scale and building scale. Regional/city scale affects comprehensive decisions about the cities. The relationship between cities, city macroform and relationship between centers are the matters of this scale. Local scale

gives more detailed information. For example, neighborhood design should be noticed. Function of buildings, transport network, distribution of functions, accessibility to activities, and the safety of pedestrian paths can be given as examples in detail. Lastly, building scale can be defined as architectural scale. Entrance of the buildings, their façades, circulation inside the building, floor functions are the matter of this scale. In the study of Cervero and Kockelman (1997), three indices are introduced. Firstly, site design is defined as the proportion of commercial-retail and service parcels. Size and shape of the places are significant to create desirable places (Adelaide City Council, 2011). Places should be in walking distance. Comfortable and safety pedestrian ways are a requirement to increase connectivity between places and to decrease car dependence. Secondly, pedestrian and cycling levels are analyzed with different indices:

- (1) Proportion of blocks with sidewalks, planting strips
- (2) Proportion of intersections with signalization
- (3) Averages of building length, pedestrian way width
- (4) Bicycle lanes

Pedestrian way as one of the most important element for city should be comfortable, accessible, well defined and safe (Adelaide City Council, 2011). To provide these characteristics, building design, pavement, function of the building, street design, parking area and signage are main elements to be considered. Lastly, streets are important for the accessibility. They affect both vehicle and pedestrian traffic. Therefore, the design of streets shapes the development of the city. Cervero and Kockelman (1997) analyze the design of streets under four topics: (1) prevailing pattern such as regular grid and curvilinear grid; (2) proportion of intersections; (3) number of freeway under and over-passes, freeway miles, number of blocks, and number of dead ends and cul-de-sacs; (4) averages of speed limits and street widths.

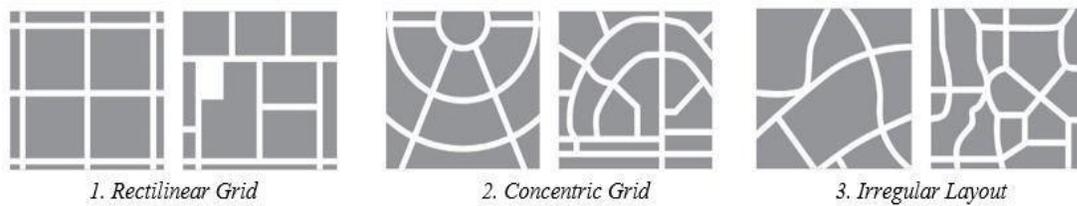


Figure 4-1 The types of street pattern (The Scottish Government, 2010)

The form and design of urban areas are an instrument for encouraging public transport. Public transportation systems are used as a tool to decrease the dependency of automobile in the developed and developing countries because of providing high quality and fast service. These are also used for reducing the environmental impacts of private car.

Mobility patterns of people are affected by land use planning. Researchers analyze that when people are encouraged to live in more sustainable urban forms, it is expected that negative environmental impacts decrease. This situation causes to decrease the travel need or decrease the distance required to travel. People tend to live in close distance to major urban centers. This situation causes to shape cities in three different ways: the walking city, the transit city and the automobile city (Newman & Kenworthy, 1996).

Trains and trams thrust the city outwards after the developments in transit technology. In the center, around the train station could be defined as walking city which was connected by trams. It created a linear development along the corridor. The main focus of the city was the central area. The density changed into medium density (50-100 people per ha, diameter of 20-30 km) (Newman & Kenworthy, 1996).

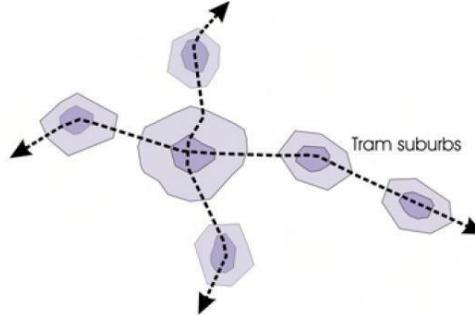


Figure 4-2 Transit city with medium density (Gillham, 2002)

After the Second World War, automobile technology affected the shape of the city. New housing areas developed with low density (10-20 people per ha) because of the industrial city. Zoning was useful for urban planning in these years. Increment in the automobile dependency caused the increment of travel distances.

After the oil crisis in 1970s, public transport has been seen once again. After 1980s, most of metro systems and light rail systems have been built in the city. Moreover, bus rapid transit systems (BRT) were also used as a cheaper public transport mode in the developing countries. North America and West Europe started to integrate bus transit systems and rail transit systems after the success of BRT systems. In brief, the main investments in the world were public transit systems in those years.

A sustainable city has a medium density (over 40 people per ha) with mixed land use and accessible public transit corridors. The city would have lengths in walking and cycling distance. The usage of automobile decreased because of public transport priority.

For encouraging people to use public transit systems, public transit station design with integration of different modes and electronic fare systems gains importance. In a sustainable manner, investment of public transit infrastructure needs ‘macro’ land use and ‘micro’ neighborhood design because it is not enough to change travel behavior. According to this, major activities should be well connected to each other. People

should use public transit system or walking or cycling for accessing to their jobs and other activities from their houses.

Traditional and neo-traditional neighborhood design enables people to walk or cycle and use public transit systems. While Handy (1993), Friedman et. al. (1994), Kennedy et. al. (2005) and Cervero & Radish (1996) emphasize the righteousness of this idea while Friedman et. al. (1994) add that neo-traditional neighborhood design reduces the automobile dependency. Well-defined street network for pedestrians and bicycles in residential and non-residential areas cause dense usage for neo-traditional neighborhood design.

Sustainability, urban form and transport issues are analyzed by many researchers who support pedestrian-friendly and public transit friendly design. While Newman and Kenworthy (1996) wrote about New Urbanism, Jabareen (2006) came up with neo-traditional design approach and Arth (1999) focused on New Pedestrianism approach.

4.2.1 Physical Factors

a. Imageability: Physical elements and their harmony allure people and impress their feelings. Different physical elements promote to imageability such as buildings with different forms or colors, historical buildings, and special and different land uses. For example, shops, popular restaurants, public places such as hospitals, parks, and schools make a place imageable. ‘Landmark’ is the most important element that influence imageability (Purciel & Marrone, 2006). Landmarks improve legibility of urban space and create memorable places in people’s minds. Built forms define ‘nodes’ in cognitive maps of people. Nodes such as junctions and form of buildings contribute to increase legibility of urban space and help to identify landmarks in cognitive maps.

b. Legibility: Kevin Lynch (1960) defines legibility in his book, “The Image of the City”, as “the ease with which its parts can be recognized and can be organized into a coherent pattern”. The author claims five significant parts to make city more legible: paths, nodes, edges, districts and landmarks. According to Lynch, a legible city “would

be one whose districts or landmarks or pathways are easily identifiable and are easily grouped into an over-all pattern”. Therefore, legible city promotes to create cognitive map and makes city describable easier.

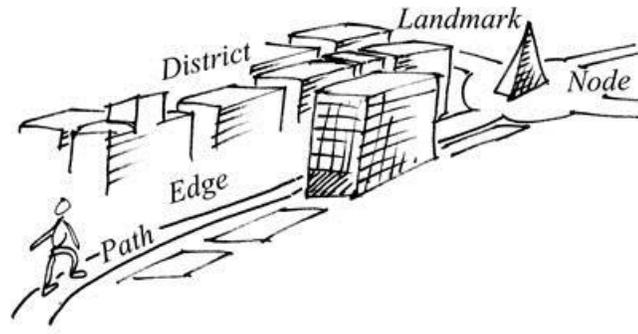


Figure 4-3 Five elements of Kevin Lynch

c. Enclosure: It is “the degree to which the edges of the street are defined” (Jaskiewicz, 2000). There are two important feature to estimate the grade of enclosure in an urban space:

- i. *Long sight line:* is the skill to see at least 300m or about three city blocks within the breadth at any point along walking.
- ii. *Street wall:* is an edge throughout the sidewalk and adumbrate like a wall. Some elements contribute to make street wall such as façades, gates, and greenery. To adumbrate like a wall, the elements should have specific proportions. For example, façades and construction sites should be over 1,5m (Purciel & Marrone, 2006).

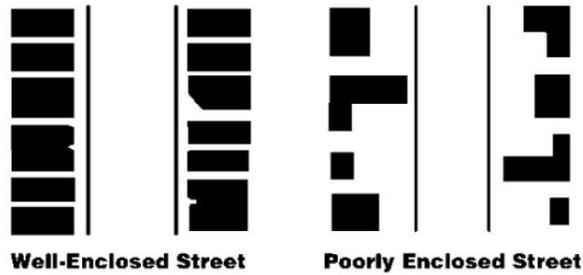


Figure 4-4 Schematic display of well-enclosed and poorly enclosed street
(Jaskiewicz, 2000)

Human scale, building orientation and street furniture affect the pedestrian enclosure. There should be convenient width of footway that supply pedestrian flow and their activity for human scale within enclosed street. Minimum width of footway should be about 1,525 m to meet the needs of pedestrian (Axelson, et al., 1999). For building orientation, Jacobs (1993) claims that the ratio between height (vertical) and width (horizontal) should be 1:2. According to him, this building orientation is not enough alone and there should be secondary elements to strengthen the feeling of closure (Jacobs A. B., 1993). The last important element is street furniture to provide the feeling of enclosure. Several street furniture and trees create security zone from vehicle traffic (LA Walkability Checklist, 2008) and assist to provide human scale factor.



Figure 4-5 The role of street furniture (LA Walkability Checklist, 2008)

d. Human scale: It can be defined as functional width of street that provides pedestrian flow and their activity. To create design with human scale, the size and form of physical elements should be proper (Purciel & Marrone, 2006). For example, if the building height is excessively high and there is no places on eye level, people feel oppressed. There are several urban features to make places with human scale. For example, eye level-showcases, quantity of windows, small flowerbeds and gardens in front of buildings, and street furniture are urban elements associated with human scale.

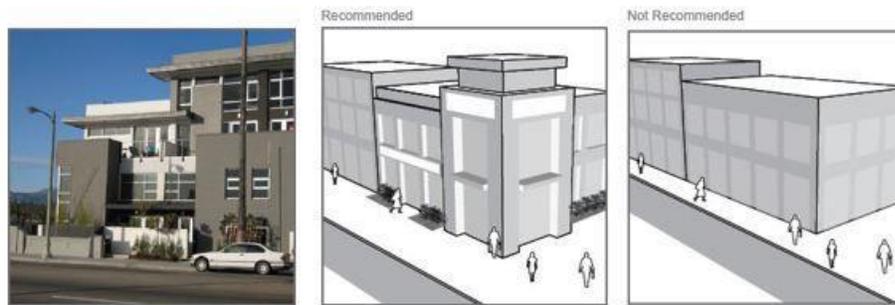


Figure 4-6 Example of human scale (LA Walkability Checklist, 2008)

e. Transparency: Jaskiewicz (2000) defines transparency as transition between spaces such as public and private. Transparency differs in a commercial place from a residential place. In a commercial place, large showcases, cafes and restaurants through footway and interior display can provide high level of transparency. On the other hand, number of windows at eye level and absence of street wall are two factors which provide transparency in a residential place. In addition, porches are another element providing transparency and connecting between public and private space. It should not be forgotten that active usage of buildings supports transparency. Cafes, parks, schools, and apartments can be defined as active-use buildings.

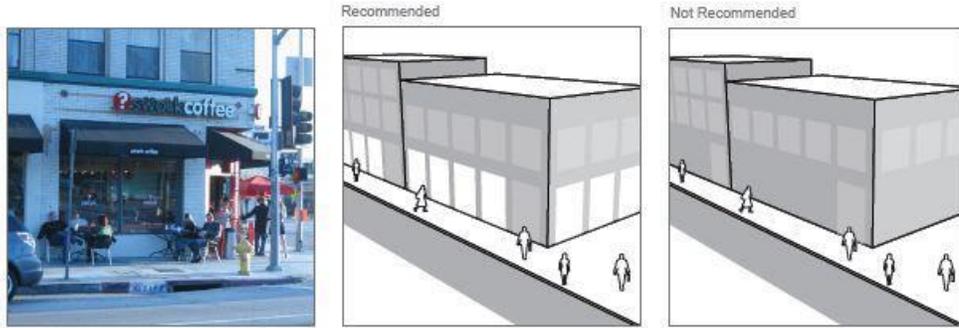


Figure 4-7 Windows at eye-level provide transparency (LA Walkability Checklist, 2008)



Figure 4-8 Transparency provides transition between spaces (LA Walkability Checklist, 2008)

f. Complexity: Visual richness supports the formation of complexity of a footway. Different building types, variety of architectural styles, façade of buildings, and variety and quality of street furniture can align as the examples of visual richness. In particular, building forms, colors, materials, number of windows and doors, variety of lightings and density of pedestrian traffic are more effective on rising complexity in urban space (Purciel & Marrone, 2006). Moreover, parks, plazas, different trees, plants and different natural elements provide to create spatial complexity of urban space (Purciel & Marrone, 2006).

4.2.2 Personal Factors

- a. *Sense of safety*: Safety can be examined into two topics as actual safety and perceived safety. Actual safety refers to safety which is provided by physical features in urban space. There are several ways to achieve actual safety. The most essential element is activity. If urban space is active, people feel safe and vice versa. According to Montgomery (1998), there are two interrelated factors to generate activity in urban space: ‘vitality’ meaning the density of pedestrian flow during different times of a day and ‘diversity’ meaning different land uses. On the other hand, perceived safety meaning to sustain security of pedestrian from the negative feeling of crime activity and danger of traffic is another aspect of safety. There are different ways to ensure perceived safety. For example, when the street is well enclosed with perpetual buildings, and eye-level street, this situation discourages crime and rises the sense of safety. Furthermore, orientation of building and transparency reduce unsecure spaces (Jaskiewicz, 2000). Jacobs (1961) mentions about three important characteristics of perceptual safety in her book “The Death and Life of Great American Cities”. First, there should be clear border between public and private space. Secondly, orientation of buildings on street should be eye-level. Lastly, there should be more common use facilities and public places on eye-level along street.
- b. *Sense of comfort*: There are several factors affecting comfort of the urban space. The simplest factors are pavement, floor quality, air condition, and shade elements. Continuous pavement, which is also called as perceptual continuity, provides to move freely without any interruptions. When there is not any interruptions on pathway, people feel more comfort. Furthermore, floor quality provides actual safety and comfort for pedestrians. The materials and standards which are used for pedestrian floor gain importance for providing comfort (LA Walkability Checklist, 2008). Another factor is air condition. It means that provides ideal air condition for pedestrians. In other words, a pleasant heat should be supplied in cold weather

and a partly cool air should be provided in hot weather. Shade elements have a great role for increasing aesthetic quality, activity and comfort. Overhangs, awnings, canopies and rooflines are the example of shade elements for used both commercial and residential spaces. They increase comfort level by providing shadow in hot days and shelter from rain and snow. Besides them, natural elements are also essential elements to provide comfort. For example, trees create enclosure and support shadow and shelter in sunny and rainy days.



Figure 4-9 Continuous pavement increases the comfort of pedestrian (LA Walkability Checklist, 2008)

- c. **Lighting:** Lighting and visibility affect feeling of safety. The quality of lighting influences not only people but also drivers. Sufficient and proper lighting provide visibility. When people are in place with proper and sufficient lighting, they feel safe. Furthermore, proper lighting can enhance the level of safety from the point of crime activity and motor vehicle. Lighting standards are not the same for all places. They are generally lower for residential area than commercial area (Jaskiewicz, 2000). Although this situation promotes the vitality in commercial center, it discourages people to access from their home zone.

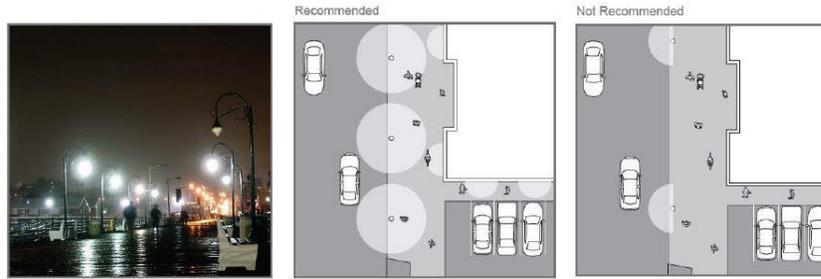


Figure 4-10 Well-lighted places make feel safety (LA Walkability Checklist, 2008)

4.3 Tram Design

A tram which is also known as tramcar and streetcar is a rail vehicle which is used for public transportation. It runs on public urban street and on segregated right of way. Tramways powered by electricity. When tram systems are used in the cities, they are called as light rail systems.

There are many tram systems throughout the world. Tram and light rail systems operate in 388 cities across the world. LRT carries approximately 45 million passengers daily. While the longest systems are in Melbourne (256 km), Saint Petersburg (205 km) and Katowice (200km) follow it. The most intensely used networks are in İstanbul, Hong Kong, Tokyo and Sarajevo (UITP, 2015).



Figure 4-11 Improvement of tram system

The major source for CO₂ emissions defines as private cars nowadays that climate change issues are important. The interest in public transit system, especially on rail, is rising with the ecological movement (van Nes, 2011).

Tram is a city's desire and a symbol. Because of that tram system and its environment should be designed well. Tram system should be accessible for all groups living, working and visiting the city. In addition, tram system should be well-integrated with other transport modes. Moreover, tram stop locations and their design should be serve travelers effectively. Tram stop plays a role as catalyst to regenerate areas (Tram design manual, 2005).

There are two main tram vehicles. First, low floor tram allows passenger also disabled passenger to get on the vehicle easily. The floor is 300-360 mm above top of rail. On the other hand, ultra-low floor tram has the lowest floor height. The height is at sidewalk height about 180 mm which provides easy accessibility for passengers in wheelchairs or with baby carriages. Moreover, articulated trams which have two or more vehicles can carry more passengers.

According to RTD Transit Access Committee (2009), station design is as important as the other factors. As Tumlin (2012, p. 217) argued:

In the vocabulary of a city, transportation is the verbs: walk, ride, access, travel. Transit station areas.....are different. They are the nouns: places and things, anchoring transportation services with locations. Planning for station areas is therefore different from planning for transportation systems and it requires a different mind-set about both access and activity.

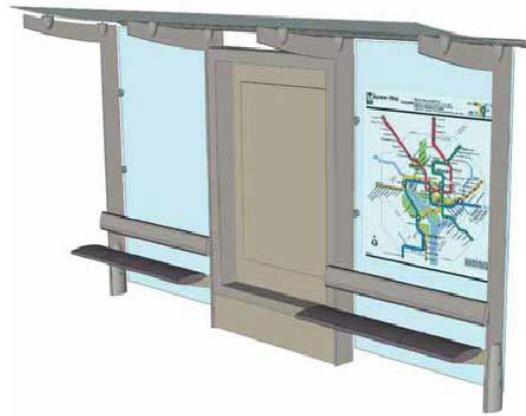
He defines six factors for pedestrians that should be given an importance planning the transit station are:

- Safety
- Security
- Directness
- Ease of entry
- Comfort
- Aesthetics

Frequency of transit service has a great role for decision to walk or drive. People have a tendency for walking to transit station in walking distance (between 400m and 800m) but they prefer to walk shorter distances (less than 150m) to transfer. In addition, parking areas, platforms and the facilities affect the decision of walking or driving.

Edinburgh Planning Committee (2005) states that “Tram vehicles should be timeless, distinctive and elegant in appearance- they should have a strong and instantly recognizable identity.” Moreover, it should be safe and usable for both the passengers and the staff. Accessibility to the facilities should be easy. In addition, it should have regard to sustainability criteria.

Tram stops include platforms, shelters, street furniture, signs, ticket machines, lighting, CCTV and equipment cabinets but every tram stops does not have the same requirements. Tram stops should provide a secure and comfortable space for the users. In addition to that, tram stops should be clearly visible by the users. All tram stops should be designed to be visually coherent. The height of tram platforms should be designed according to the tram vehicles and the platforms should be accessible for all users. There should be avoided from abrupt changes in level, steps and railings. The height of tram platform changes between the standard 18 cm and 25 cm for accommodate vehicles with bridge plates or 35 cm for accommodate vehicles with level boarding (District Department of Transportation, 2012). Surface material should be selected according to the city’s standards for streets. Handrails which should be rounded should be used where necessary. On the other hand, shelter or canopy should be provided on each platform of every stop. Shelter should be appropriate to reduce the impact of the wind, rain, snow and sun. Furthermore, lighting levels should be efficient. Stops elements should be multi-functional. For instance, the shelter or canopy should provide not only shelter and seating places but also litterbins, lighting, information and space for advertising.



*Figure 4-12 Shelter perspective view
(District Department of Transportation, 2012)*



*Figure 4-13 Sketch for tram stop
(National Association of City Transportation Officials, 2016)*

4.4 Practices for Urban Design in TOD and Transit Stations

4.4.1 Land-use and Density, TOD Guidelines for Edmonton

TOD Guidelines, prepared by the City of Edmonton and Departments of Sustainable Development and Transportation Services and approved by Edmonton City Council in 2012 identified appropriate TOD around LRT stations to integrate transit and land use. The guidelines are developed to improve livability, shift transportation modes, sustain the environment, transform urban form and diversify economy. Land Use and Density/Intensity Guidelines identified minimum and maximum land use for new land uses and station area plans. Residential densities and employment intensities are given as net area calculations (City of Edmonton, 2012). In addition to land use and density/intensity guidelines, building and site design, and public realm guidelines (streets, block size, pedestrian and bicycle connections, urban parks and plazas), urban design and crime prevention through environmental design principles were categorized. The TOD Guidelines was prepared to evaluate zoning and re-zoning implementations on sites within 400 m. of existing or planned LRT stations or transit centers. In these situations, the Land Use Type and Intensity Guidelines were to evaluate the proposed location and density of the development, regarding the Station Type.

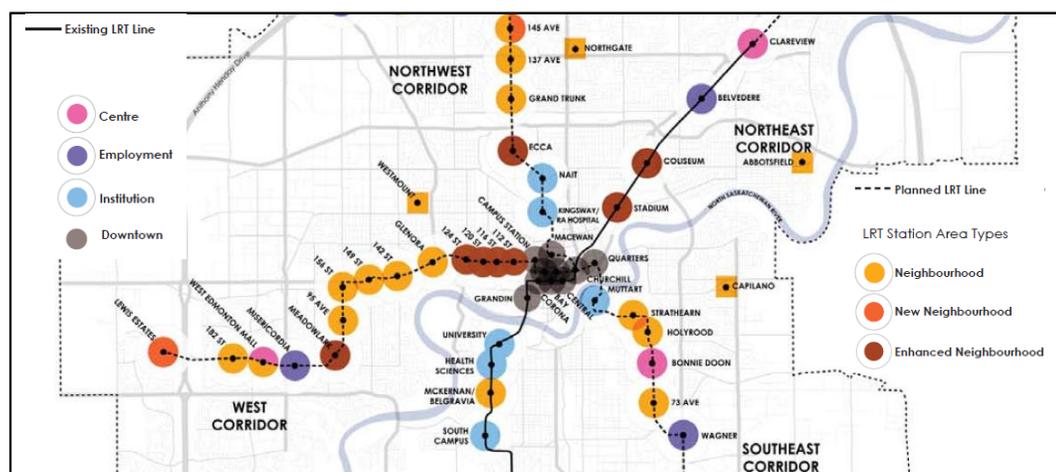


Figure 4-14 Station Area types of Edmondo (city of Edmondo, 2012)

Based on existing uses, the amount and location of potential development or redevelopment areas, existing parks or open spaces, roadway traffic conditions, street pattern and infrastructure, pedestrian and bicycle connectivity and physical barriers in the accessibility to stations, the seven Station Area Types (neighborhood, new neighborhood, enhanced neighborhood, center, employment, and institution/recreation and city center/downtown) were identified. Station area types for Edmonton are shown in Figure 4-14. Land use and density/intensity guidelines were defined for each station area type in City of Edmonton (2012). They are given in Table 4-4. Detailed guidelines specific to institutional/recreation areas have not been proposed because institution/recreation master plan exists, guidelines for the neighborhood station area type were proposed to be applied within 400 m. of the LRT station or transit center.

Table 4-4 Land Use and Intensity/Diversity Guidelines for LRT and Transit Center Station Areas (Adapted from City of Edmondo (2012))

STATION AREA TYPE	Sites within 400 meters of the LRT platform or Transit Center	
	Residential (NET)	Employment
	Neighborhood Infill development settings; TOD promotes a mix of uses	
	Sites within 400 m. <ul style="list-style-type: none"> • For sites 1.0 ha or larger: 125 du/ha min; • For sites fronting a collector road: 42 du/ha min to 125 du/ha max; • For sites fronting an arterial road: 63 du/ha min to 125 du/ha max; • For all other sites: 42 du/ha max. 	<ul style="list-style-type: none"> • Appropriate on arterial or collector roads, located above ground floor retail.

Table 4-4 (Continued)

	<p>New Neighborhood Predominately greenfield development settings; TOD promotes a mix of station- and residential-supportive uses, and ensure development in these areas.</p>	
	<p>Sites within 200 m.</p> <ul style="list-style-type: none"> • For sites 0.25 ha or larger: 125 du/ha min; • For all other sites: 63 du/ha min; <p>Sites within 200-400 m.</p> <ul style="list-style-type: none"> • For sites 0.25 ha or larger: 63 du/ha min; • For all other sites: 42 du/ha min. 	<p>Sites within 200 m.</p> <ul style="list-style-type: none"> • Appropriate on sites with direct access to an arterial or collector road. 1.0 FAR min. <p>Sites within 200-400 m.</p> <ul style="list-style-type: none"> • The same as for sites within 200 m.
	<p>Enhanced Neighborhood Infill and greenfield development settings; TOD ensures development in these areas</p>	
	<p>Sites within 200 m.</p> <ul style="list-style-type: none"> • For sites 0.25 ha or larger: 225 du/ha min; • For all other sites: 125 du/ha min; <p>Sites within 200-400 m.</p> <ul style="list-style-type: none"> • For sites 0.25 ha or larger: 225 du/ha min; • For sites fronting an arterial or collector road: 63 du/ha min to 125 du/ha max; • For all other sites: 63 du/ha max. 	<p>Sites within 200 m.</p> <ul style="list-style-type: none"> • Appropriate on sites with direct access to an arterial or collector road. 1.0 FAR min. <p>Sites within 200-400 m.</p> <ul style="list-style-type: none"> • The same as for sites within 200 m.

Table 4-4 (Continued)

	<p>Center Infill settings only; The uses allowed in TOD will include retail, office, commercial and higher density residential.</p>	
	<p>Sites within 200 m.</p> <ul style="list-style-type: none"> • For sites 0.25 ha or larger: 225 du/ha min; • For all other sites: 125 du/ha min; <p>Sites within 200-400 m.</p> <ul style="list-style-type: none"> • For sites 0.25 ha or larger: 225 du/ha min; • For sites fronting an arterial or collector road: 63 du/ha min to 125 du/ha max; For all other sites: 63 du/ha max. 	<p>Sites within 200 m.</p> <ul style="list-style-type: none"> • Appropriate on sites with direct access to an arterial or collector road. 1.0 FAR min. <p>Sites within 200-400 m. The same as for sites within 200 m.</p>
<p>du/ha: dwelling units/ha</p>	<p>Employment Infill and greenfield setting; Allowable uses include office, commercial, retail, higher density residential and park & ride facilities.</p>	
	<p>Sites within 200 m.</p> <ul style="list-style-type: none"> • For all other sites: 225 du/ha min; <p>Sites within 200-400 m.</p> <ul style="list-style-type: none"> • For sites 0.25 ha or larger: 225 du/ha min; • For sites fronting an arterial or collector road: 63 du/ha min to 125 du/ha max; For all other sites: 63 du/ha max. 	<p>Sites within 200 m.</p> <ul style="list-style-type: none"> • Appropriate 1.0 FAR min <p>Sites within 200-400 m.</p> <ul style="list-style-type: none"> • Appropriate on sites with direct access to an arterial or collector road 1.0 FAR min.

4.4.2 Diversity, TOD Projects in the United States

Urban design is an important aspect of making transport as well as TOD projects work and it is a good way of structuring intensive land uses and multiple transportation modes. Jacobson and Forsyth (2008) analyzed different TOD projects in terms of urban design and discussed these practices for future TOD projects. Seven TOD projects in the United States using six different types (geographical location, development period, dominant land-use type, levels of affluence/income group of residents, scale of development, roles of planners and developers) were analyzed in order to evaluate existing guidelines for TOD projects. The case study locations were: Rosslyn, Clarendon and Ballston in Virginia (VA); the Delmar Loop in Missouri (MO); Emerson Park in Illinois (IL); and Oakland City Center/12th Street and Fruitvale in California (CA). General characteristics of three of seven cases (each from case states) were summarized in Table 4-5.

Table 4-5 TOD case studies in the United States (Adapted from Jacobson and Forsyth, 2008)

Washington, D.C. Area	
<ul style="list-style-type: none"> • Washington, D.C. Metro is one of the oldest and well established transit systems in United States. • Arlington County had carried out planning and policies to support Metro. • Clarendon: First plan for Clarendon was released in 1984 with a vision of an urban village. Greater development around the station was proposed. 	

Table 4-5 (Continued)

East Saint Louis Area	
<ul style="list-style-type: none"> • East Saint Louis Metro Link LRT is newer. • Planning has been fragmented. • Emerson Park: TOD was developed through community activism. It has been proposed to initiate for the redevelopment of the housing stock. Non-profit developers have played an important role. 	
Oakland Area	
<ul style="list-style-type: none"> • In the Bay Area Rapid Transit (BART) Oakland cases provide good examples of TOD's development with different densities. • Fruitvale: A mixed land-use center of small-scale commercial shops and apartments was proposed. 	

Urban design score sheet, urban design inventory and photographic visual assessment were applied to three of the seven cases while mapping (GIS-based analysis) was used for all cases. Even though assessment methods demonstrated diversity among TOD areas, the cases shared some common characteristics.

Urban Design Score Sheet (Ewing et al. 2005) evaluates walkability level of a mixed residential and commercial area. Applied by TOD planners, it provides scores on several dimensions such as imageability, enclosure, human scale, transparency and complexity (visual variety). In (Jacobson and Forsyth, 2008) it was found that three cases (Clarendon, Emerson Park, Fruitvale) were highly imageable and had high complexity according to the Urban Design Score Sheet.

Urban Design Inventory (Day et al. 2006) measured the presence or absence of urban landscape components such as ease of movement, pleasure or attractiveness and perceived safety. Even though it roughly assessed quality for some components, it approximately combines different urban design concepts. In *Urban Design Inventory* of Jacobson and Forsyth (2008), enclosure and transparency varied according to density in three cases. Clarendon and Fruitvale had many commercial uses while Emerson Park exemplified front terraces and more vacant buildings.

TOD	1 mile square figure-ground	Businesses per ha 400 m from station	Businesses per ha 800 m from station	Average block size (ha) for 800 m buffer
Rosslyn (VA)		6.1	16.9	3.34
Clarendon (VA)		4.1	11.1	1.81
Ballston (VA)		4.5	9.6	2.21
Delmar Loop (MO)		1.1	1.7	1.96
Emerson Park (IL)		0.3	0.2	2.33
Fruitvale (CA)		2.3	4.3	2.25
Oakland City Center/ 12th St. Station (CA)		21.6	38.9	1.52

Figure 4-15 Case study characteristics (Jacobson & Forsyth, 2008)

GIS based Analysis (Jacobs, 1993; Southworth, 1997; Forsyth, 2005) of street networks and levels of mixed land-uses investigates figure-ground and intersection densities. Intersection densities are related to the interconnectivity of streets, which means that more intersections are more movement in an area. GIS-based analysis of Jacobson and Forsyth (2008) showed the differences between block sizes of the TOD projects. It was found similar across the TOD examples. Only Rosslyn had block size, ranging between 1.5 and 2.5 ha. Business counts varied greatly. Businesses per ha. within 800 m. of the stations were differentiated between 0.2 in Emerson Park and 39 in Oakland City Center. Figure 4-15 summarizes the analysis of mixed land-use.

Photographic Visual Assessment compares different projects, regarding six issues, i.e., color, form contrast, line, texture contrast, scale contrast and scale dominance, and spatial dominance. It was based on work on visual impact assessment. Photographic Visual Assessment of Jacobson and Forsyth (2008) showed that Fruitvale had the highest level of complexity while Clarendon (more historic) and Emerson Park (more residential) had less complexity.

4.4.3 Accessibility, LRT Stations Along The Green And Gold Lines In Los Angeles

In Loukaitou-Sideris et al. (2013) the importance of urban design was stated in the success of transit stations. In the United States, state and city transport institutions have been constructing LRT systems in and above motorway medians; however, if the LRT stations or transit centers do not have good design in the connection to the neighborhoods and communities around them, the investment has no effect in reducing land costs, minimizing traffic congestion and decreasing commuting times. Elevated stations are the ones which are difficult to physically reach or arrive. Loukaitou-Sideris et al. (2013) analyzed 14 elevated and motorway median LRT stations along two rail lines (the Green and Gold) in Los Angeles and examined four elevated Green line stations to integrate them to the surrounding neighborhoods.

The followings are given as measurable factors in station accessibility.

- *Cumulative amenities*- the number of services or commercial stores and institutional facilities such as groceries, parks, banks and other commercial stores within 400 m.,
- *Cumulative disamenities*- the number of services or stores, facilities that have negative effects on walkability or the perception of personal safety such as off-brand motels, alcohol beverages stores or adult entertainment facilities as well as gas stations, drive and eat stories or auto repair shops
- *Infrastructural barriers to accessibility*- the ratio of surface land occupied by freeways and freeway ramps within 400 m.
- *Connectivity of the pedestrian network*- intersection density, the number of unbroken pedestrian paths, the horizontal distance from the platform to nonresidential area, number of station entries, distance from station to marked bicycle lanes, number of bicycle parking, and number of transit stations within 400 m.,
- *Visibility and legibility*- the visibility of station entries and exits, the legibility of directional signs, obstructed/unobstructed view from one point to another across the station area,
- *Platform accessibility*- ease of accessing the platform from the entrance, the number of station entries, number of elevators and escalators, number of directional changes, and vertical and horizontal distance from the platform median to the entrance,
- *Environmental condition*- the level of positive environmental factors such as street trees, street art, lighting, well-designed and maintained buildings or negative environmental factors such as graffiti, garbage, vacant lots and buildings, poorly designed or maintained buildings as well as noise and pollution (Loukaitou-Sideris et al., 2013).

Some types of elevated and motorway median stations have some negative effects on accessibility and they have weak links to their surrounding neighborhoods. Nevertheless, urban design interventions can be implemented to improve the station's accessibility and connectivity. In Loukaitou-Sideris et al. (2013), four categories of design interventions were defined. They were called as architectural interventions, landscape and mobile urbanism interventions and perceptual links. Four case stations of Green Line were selected to demonstrate the applicability and properness of urban

design interventions for a specific station. In the case studies, each station exemplified a different type of intervention. All four were El Segundo for No Interruption case, Avalon for Linear Interruption, Rosa Parks for Single Interruption and Harbor for Multiple Interruption case. The following example demonstrates the linear interruption case (Figure 4-16 and Figure 4-17).

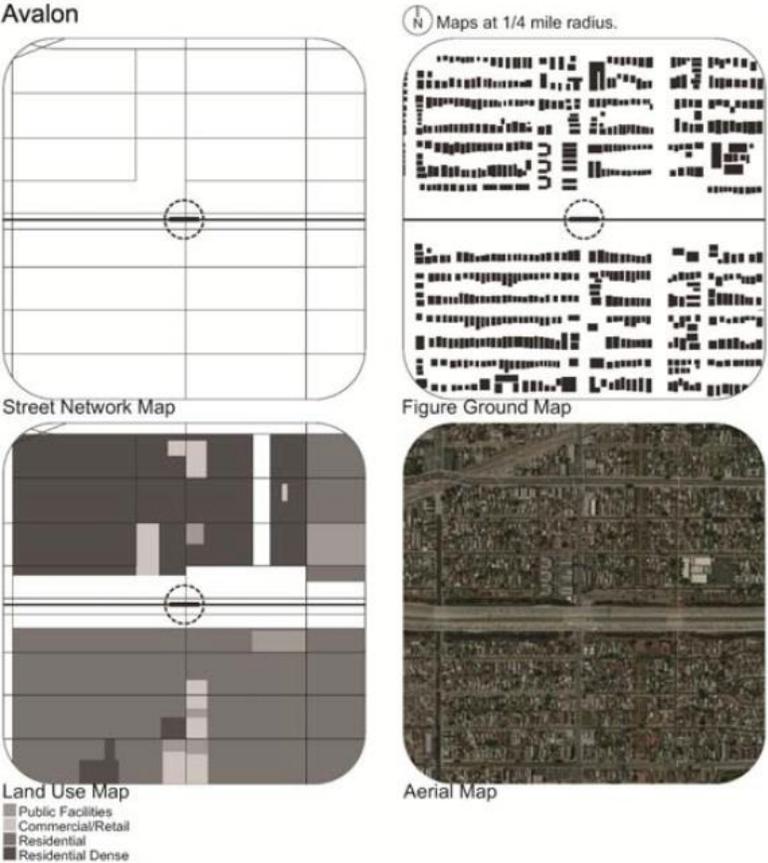


Figure 4-16 Analysis of Avalon Station (Loukaitou-Sideris et al., 2013)

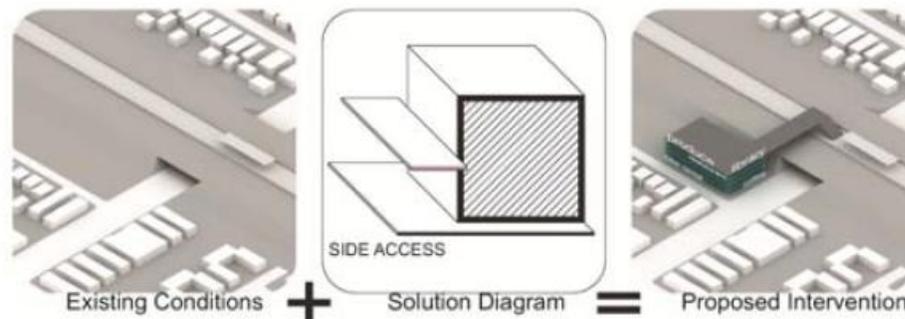


Figure 4-17 Linear interruption station example, Avalon Station (Loukaitou-Sideris et al., 2013)

Avalon Station, located in the median of the Golden State Motorway in the South Los Angeles, serves as a transfer point between the Green Line and many local bus lines as well as shuttle services. The surrounding land area is generally occupied by single or multiple-family houses. Within 400 m. neighborhood-based commercial and public services such as churches and community gardens, parks are distributed. As the station serves residential area and many facilities and services are proper for TOD; however, an urban design intervention is necessary to increase the accessibility and connectivity of the transit station. The lack of vacant lots within 400 m. is a challenge for development but a large parking lot on the northeast side of the station could provide land for development. Under these conditions the Avalon Station was proposed for Linear Interruption. Side access, layered ground, new paths, and viaduct were the interventions that were analyzed to make the Avalon Station a multi-modal hub, street-level pedestrian access under the motorway, and immediate access from the platform to the transfer points for other transit modes at street level Loukaitou-Sideris et al. (2013).

4.4.4 Connectivity, TOD Guidelines for Denver

TOD strategic plan was intended to plan and guide the critical urban actions for successful TOD in Denver. Since the 2006 the strategic plan was identified for multiple stations, which were planned and needed infrastructure improvements. Strategic

Planning is important to success TOD for several reasons. Station area plans had identified needed but they were unfunded. At several stations there were barriers to TOD implementation. Stations were at different levels of development readiness for TOD while the City had limited resources to implement. Organization and arrangement of City departments' approaches to TOD improved efficiency. Some station areas were of first priority to implement TOD in short-term so financing strategies were developed to stimulate investments (TOD Strategic Plan, 2014).

The City of Denver defined TOD as an idea of developing transit communities, which were walkable and livable. To provide citizens high access to their daily needs six TOD principles were outlined. The following TOD principles provided a base line for Denver neighborhoods.

- Connect (Entry Point- access to the regional economy; First/Last Mile- walk, bike, bus; Access to All- connect to newly developed and old neighborhoods),
- Innovate (Sustainable- economic, social, environmental; Equitable- for all; Global Economy- compete on the world),
- Efficient (Location- one place to live, work, and recreate; Shared Resources- reduce cost of infrastructure; Balance- jobs and homes nearby to reduce travel and commuting times),
- Place (Active- promote safety and visual interest; Vibrant- bring together people and activities; Destination- public life in public spaces),
- Mix (Choice- housing, jobs, shopping; Diversity- various groups of incomes and ages; Resilient),
- Shift (Car Free/ Less Car- becoming non or less car dependent; Public Space- space for pedestrians and bikes; Reduce and Energize- decrease in carbon emissions and increase in healthy living (TOD Strategic Plan, 2014).

Denver's Station Types were classified according to five context types based on characteristics of rail station or transit center with its environment. These characteristics were land use mix, street and block pattern, building placement and location, building heights and mobility. Except for downtown stations the 34 stations in Denver were scored across market readiness, development potential and TOD characteristics such as physical form (block size), pedestrian accessibility (walking

score), bicycle accessibility, parks and their sizes as well as transit service frequency. Some of key findings are listed. Stations on existing lines had higher scores on both TOD development and market readiness. Stations, which are in close proximity to downtown, had better TOD characteristics. Urban Center stations had both market and development readiness with high development capacity. Some stations might move quickly when planning was completed. East line stations had a weaker market readiness with high development potential while west ones had a stronger market readiness with less development potential (TOD Strategic Plan, 2014). Finally, a strategic approach to implement TOD in Denver was prepared and short and long-term actions that connect cities were proposed.

TOD areas are generally bordered by their walksheds. It is the distance assumed people walk to arrive a transit station or center. For both light and commuter rail, it is estimated that people walk approximately 800 m. max. Planners and urban designers map 800 m. walksheds to evaluate connectivity, find barriers, and measure where potential infrastructure would be improved. An example of walkshed analysis for a specific station is presented in Figure 4-18. The aerial photography of Evans demonstrates that some of rail or LRT stations have less than the max. amount of land within a 10-minute walk due to barriers such as rivers, roadways and rail line corridors in Figure 4-19. On the other hand, Colorado example is to show the effects of infrastructure improvements such as a pedestrian bridge over a roadway. This improvement increase the connection of the neighborhood to the rail station.

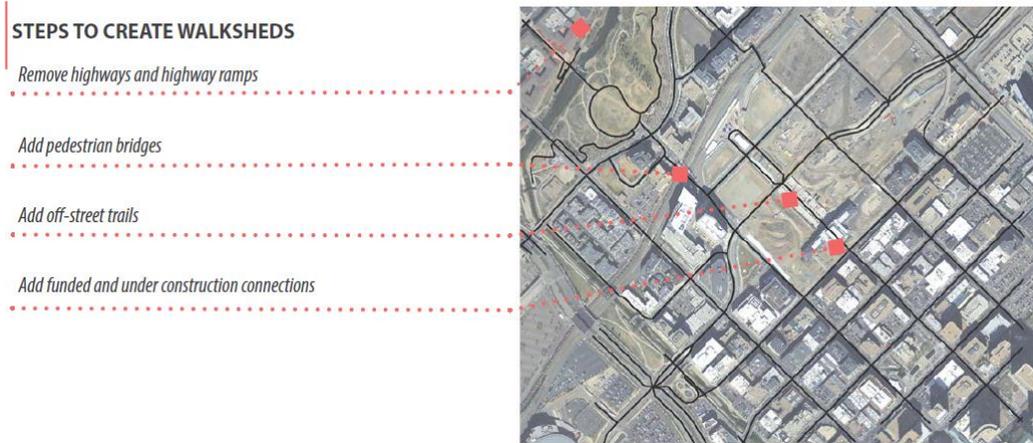


Figure 4-18 Walkshed analysis for Denver Union Station (TOD Strategic Plan, 2014)



Figure 4-19 Walkshed examples (TOD Strategic Plan, 2014)

4.4.5 Streetscape and Environmental Factors, TOD Guidelines for Ottawa

The purpose of TOD guidelines for the city of Ottawa was to provide guidance to evaluate, promote and achieve TOD. These guidelines were proposed throughout the City for all development within a 600 m. walking distance of a rail station or transit center. In parallel to the policies of the Official Plan and all other related regulations

TOD guidelines were to provide guidance to the design and review of existing city plans, site plans, zoning and rezoning regulations; assist in new community design plans or secondary plans for undeveloped or redeveloping areas; and complement design factors in approved community design plans or existing secondary plans. The TOD Guidelines are organized into six general sections: Land use, Layout, Built Form, Pedestrians and Cyclists, Vehicles and Parkings and Streetscape and Environment (TOD Guidelines, Ottawa, 2007).

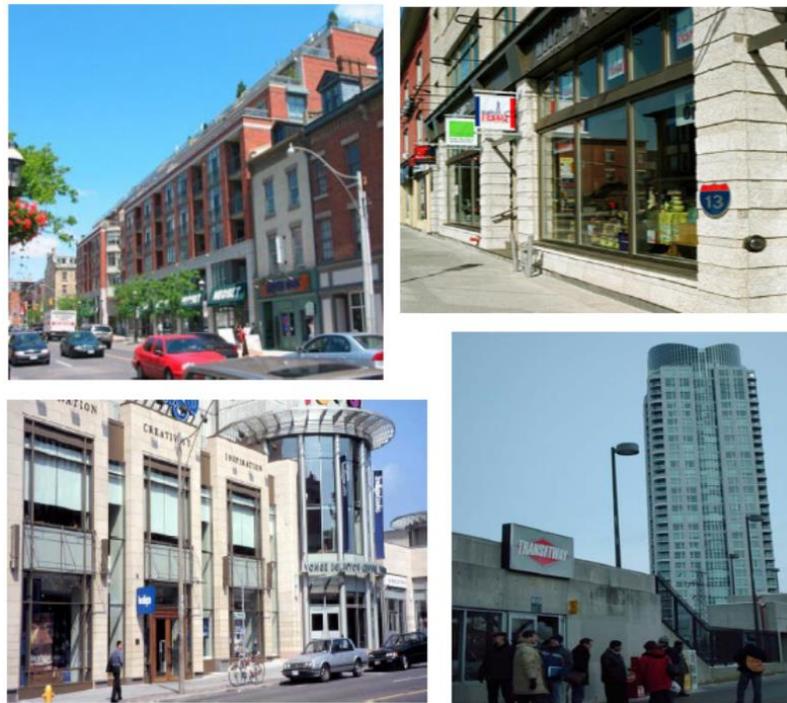


Figure 4-20 Built Form Guideline Examples (TOD Guidelines, Ottawa, 2007).

Built Form- Place-making is important in TOD. To create environments and neighborhoods that are considered to be good places and good neighbors is the purpose of these guidelines. Good urban design helps to create a more interesting and attractive environments (TOD Guidelines, Ottawa, 2007). Some of these guidelines are given as

- Step back buildings, which are higher than 4 to 5 floors, to keep a more human scale and to reduce weather impacts on the sidewalk or street (left on the top row of Figure 4-20).
- Create visible landmarks with specific design elements that are easily identified and located. Taller buildings are good to mark a location like the transit station (right on the bottom row of Figure 4-20).
- Set large buildings back from 3 to 6 m. from the front line to define the street edge and to provide some room for pedestrian movement and landscaping.
- Design architectural elements on the lower floors of buildings to provide visual interest and create attraction (left on the bottom row of Figure 4-20).
- Use transparent and clean windows and doors to make the pedestrian level façade to provide ease of entrance, visual interest and to provide safety and security (right on the top row of Figure 4-20) (TOD Guidelines, Ottawa, 2007).

Streetscape and Environment- The design of the spaces along pedestrian sidewalks and walkways is an important element in TOD. Some of these guidelines are given as

- Provide good quality seating, trees, street lighting, bicycle roads, and trashcans. A Maintenance and Liability Agreement can be used to place standard or uninstal non-standard streetscape material in the street (Figure 4-21).
- Provide seating along sidewalks and walkways longer than 50 m. and place them at scenic viewing locations. Furnish seating and other pedestrian facilities so to provide at least 2 m. of the sidewalk.
- Locate street lighting in significant areas to ensure pedestrian safety and to promote walking.
- Design lighting and location of lighting.

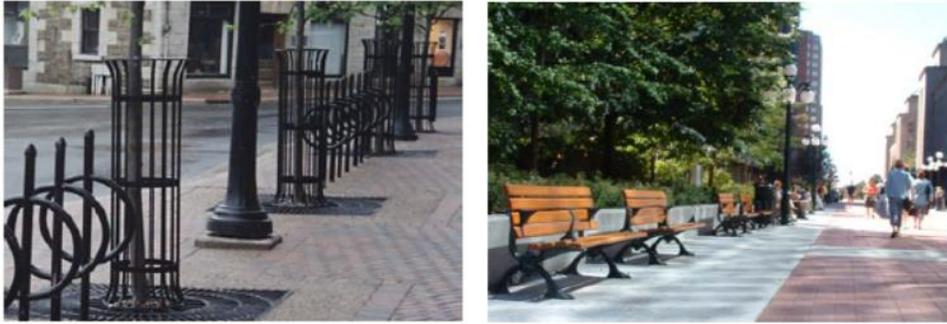


Figure 4-21 Streetscape and Environmental Guideline Examples (TOD Guidelines, Ottawa, 2007).

CHAPTER 5

GENERAL INFORMATION ABOUT ESKİŞEHİR

Eskişehir is one of the cities in north-west of Turkey. It is assigned as a junction point between Ankara and İstanbul due to its geographical position. The distance between Eskişehir and Ankara is 233 km while Eskişehir and İstanbul is 322 km. Although there is a high-speed rail to İstanbul, they do not have a great connection. The floor area of Eskişehir is 13.925 km². According to the information received from Turkish Statistical Institute (2015), the population of the city is 826.716.



Figure 5-1 Location of Eskişehir in Turkey

There are 14 districts, 15 municipalities and 546 neighborhoods in Eskişehir. The sorting of socio-economic development of the city is 7 in 81 cities. The greater part of the population gathers in the center (Tepebaşı and Odunpazarı). It can be said that

while Tepebaşı and Odunpazarı are the densest neighborhoods, Han and Mihalgazi is the least dense neighborhoods. Furthermore, while the population ratios of rural and urban area were close to each other in 1970, the difference between these ratios increased gradually for the next years. In 2010, 89% of the population started to live in urban areas. On the other hand, while migration to Eskişehir has increased between 2010 and 2015, migration from Eskişehir nearly has remained stable between those years. According to the data from TUIK (2015), the cities which allow to immigrants from Eskişehir are Ankara (11.38%), İstanbul (9.97%), Afyonkarahisar (5.49%), Bursa (5.42%) and İzmir (4.86%). In addition, the cities immigrate to Eskişehir are İstanbul (13.08%), Ankara (12.11%), Afyonkarahisar (5.36%), İzmir (5.22%) and Bursa (5.02%).

5.1 Historical and Spatial Development of Eskişehir

5.1.1 Origin

In Ancient and Medieval Age, Eskişehir was known as ‘Dorylaion’ in Greek and ‘Dorylaeum’ in Latin. In Arabic sources, the city name is given as ‘Darauliya’, ‘Adruliya’ and ‘Drusilya’. Dorylaion is located on junction point of important roads. According to Ancient resources, the city is Phrygia city which is founded by Eretrial Doryleos. The city has a reputation for thermal springs. Its wealth comes from the commercial activities. According to some travels and researches of most of travelers and scientists in 19th century, they appoint that the Ancient Dorylaion is located 3 km away on the Northeast of Eskişehir. It is determined that there is a continuous settlement from Ottoman period to Bronze Age by still progressing excavation.

Dorylaion did the honors to Byzantine Empire until the Seljukian Sultan –II. Kılıçarslan- defeated Byzantium. After that Dorylaion entered into the domination of Seljuk. They established a new settlement at south of Dorilaion and they called Dorilaion as Eskişehir which means ‘Old city’ in English (Governorship of Eskişehir).

5.1.2 From Primeval Era to 11th Century

According to the archaeological researches, first settlement was seen in 3000s A.D. In 2000 A.D, Hittites admitted Eskişehir as seigneury. In 1200 A.D., Phrygians came to Anatolia and they established Dorylaion. After Phrygians, Dorylaion did the honors to Lydians, Persians, Roman Empire and Byzantine Empire. Before the period of Ottoman Empire, Seljukians conquered the city. Because of the war between Seljukians and the Crusaders, they did not build more Seljukian monuments (Governorship of Eskişehir, 2016).

5.1.3 Ottoman Empire Period

In 1284, the Sultan of Seljuk gave the city to the founder of Ottoman Empire. The city could not develop enough until the railway line. In 1890s, the railway line reached to Eskişehir. After that, trade roused up and the city started to develop. Migrants from Caucasia, Krym, Romania and Bulgaria were placed into Eskişehir. This situation increased to population and caused city to develop (Governorship of Eskişehir, 2016). Railway affected the direction of development and the city grew towards the north of Porsuk Stream.

5.1.4 The Period of Turkish Republic

It has tried to create modern city in a short period by the investment in Republic period. In 1925, Eskişehir was a city and it had three districts –Sivrihisar, Mihaliçcik and Seyitgazi. In 2008, the total number of districts rose up to 14. Eskişehir gains the title of ‘metropolis’. After the railway line, the city started to develop. People settled towards to railway line. The railway station which is located in the center supported to the connection between villages around the center. Productions coming from the villages were collected into the center. Therefore, the relationship between rural and urban place started and the role of trade organization was brought to Eskişehir (Albek, 1991). It is truer to analyze of the development of Eskişehir into different period. After the republic was established, Turkey had different development periods in terms of economic, social and political factors.

5.1.4.1 Urban Development between 1923-1950

Ottomans did not give enough importance to the urbanization issues such as infrastructure, electrical and water issues. After the republic, especially between 1923-1950, industry has gained importance and planned period started for Turkey. Capital investments had started to condensation in Anatolia. This process affects Eskişehir in a positive way. At the beginning, it can be said that there were two basic settlements. First settlement was Odunpazarı which has still archaic characteristics. Second one was the environment of Porsuk stream. However, some public buildings, commercial units and residential places were built on empty spaces between these two settled areas. Thus, these settled areas combined with each other and the city had compact and circular form. The most important factor taking that form is site selection for industrial buildings because residential areas located around these buildings. Municipality gave public transportation service with 6 buses for the first time –in1946- due to fast spatial sprawl. It is seen that people had not needed any vehicle in these years because city was small and walkable.



Figure 5-2 Spatial uses of the city in between 1923-1950 (Ertin, 1994)

5.1.4.2 Urban Development between 1950-1960

Industrial development was at the forefront for this period. Unplanned urban development was seen after 1950 because of rapidly increasing population. Although Eskişehir was more developed in comparison with the other cities in Turkey, confusion and lack of planning made urban functions decelerate. This situation caused to start of squatted period. Center of the city became denser due to the population that is rapidly increasing. Flood disaster in 1950 damaged buildings on plain. That disaster made city to develop towards the north. Commercial and financial life developed with industry and so the characteristics of the city were identified. Spatial and social development in this period started to create urban macroform.



Figure 5-3 Land use between 1950-1960 (Ertin, 1994)

Besides the industry, one of the most important factors affecting the development of the city is railway line. The city has a junction point role because it was a focus point for freight and passenger transportation. It had enhanced the spatial impact of the railway line to have all functions of the railway line in urban macroform. Residential areas and commercial areas were built near railway station. This development brought along some necessities such as the education and health functions. These necessities

made essential a master plan. Master plan competition was hold in 1952 and Melahat Topaloğlu and M.Ali Topaloğlu won the competition. The plan was approved in 1956 and came into operation. According to these, it can be said that although industrial development has affected the city growth, railway was more effective for the macroform of the city. In other words, city started to grow along the railway on those years.



Figure 5-4 1/5000 Scaled Development Master Plan of Eskişehir in 1956

5.1.4.3 Urban Development between 1960-1980

Built-up area of the city reaches present form in this period. Besides the increasing in population and new job opportunities, construction of İstanbul-Ankara highway became an important factor affecting the development of the city. After the construction, city grew towards the north of the city. Spaces between disconnected residential areas were filled up in that period. Till 1965, the city developed as horizontal but, after 1965, development began vertical. In other words, low rise buildings left their places to the apartments after 1965. Showing a twofold increase of urban population had led to vertical growth. Housing demand and necessities resulting from increase in

population have being tried to resolve with the help of master plan in 1978, but unity in functions of the city could not be achieved. As a consequence, İstanbul-Ankara highway played a major role for the development of the city. City developed along the highway.



Figure 5-5 1/5000 Scaled Development Master Plan of Eskişehir in 1978

5.1.4.4 Urban Development between 1980-2000

After 1980, city has continued to grow vertically and horizontally. The significant factor affecting urban macroform was cooperative dwelling association in that period. While center and its around were growing with a plan, tendency of squatting increased in neighborhoods in urban peripheral. In order to solve that problem, 1/1000 scaled Implementary Development Plan (uygulama imar planı) was started to be prepared in 1980 however it could not be finished. Apartments having 2-3-4 floors in urban center and around were changed with 7-8 floors apartments by cooperative. Eskişehir Master Development Plan (nazım imar planı) and Reclamation Development Plan (ıslah imar planı) which were approved in 1986 caused the physical rising and high density in entire city. City had present macroform with these developments. In 1989, 1/5000 scaled Master Development Plan was prepared. This plan was aimed to solve wrong plan decisions. Urban road network was arranged and urban development areas were planned with that plan. However, the plan had wrong population projection so it failed

to satisfy. For satisfying the needs, 1/5000 scaled Revision Master Development Plan was prepared in 2002. Consequently, city developed as a vertical between those years.



Figure 5-6 1/5000 Scaled Development Master Plan of Eskişehir in 1989

5.1.4.5 Urban Development between 2000-2014

By increasing in population and necessities, the city required a new plan and decisions in terms of the city developing. As from 2000s, service sector has developed rapidly. Open green areas were created in different location in the city and the connection with the city center was provided. For this period, some important spatial development actualized:

- 2-line tram was built which intersect in the center in 2004.
- Factories site was transformed and Espark Shopping Center was opened.
- Theme park called ‘Kentpark’ was opened in 2009.
- Porsuk Stream and its environment were rehabilitated and recreation areas were constituted.

These developments improved tourism infrastructure for the city. However, these improvements handled the city as the point and segmental approach not as integrative approach.

➤ Revision Development Master Plan in 2002

Master Development Plan in 1989 became unsatisfied and it needed to make a revision. According to this plan, new residential and social reinforcement areas were suggested. Sub-center was recommended in factories site by transformation. Regulation in transportation was made with this plan. Light rail system with two lines was suggested. It is seen that light rail system affected the city development. City grew around tram stops.

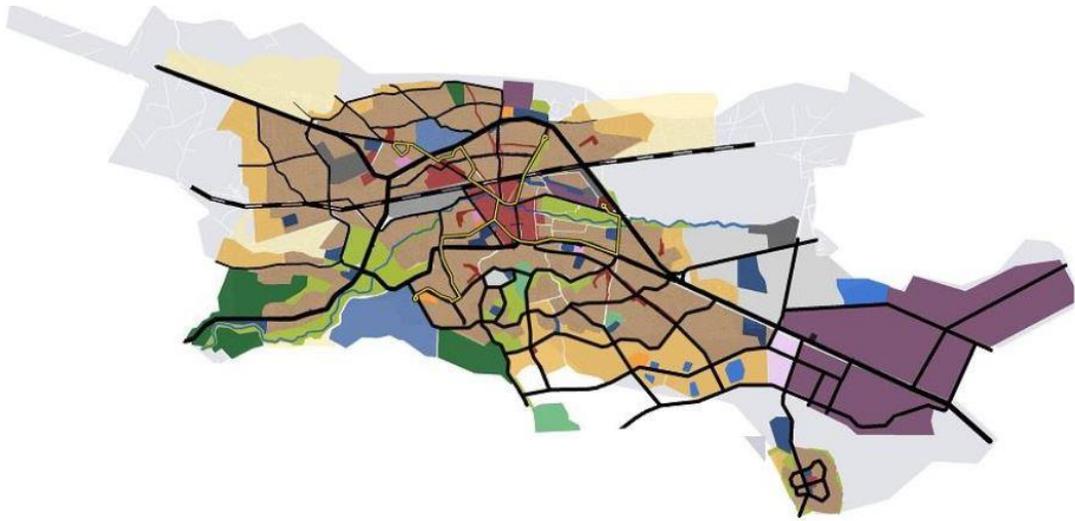
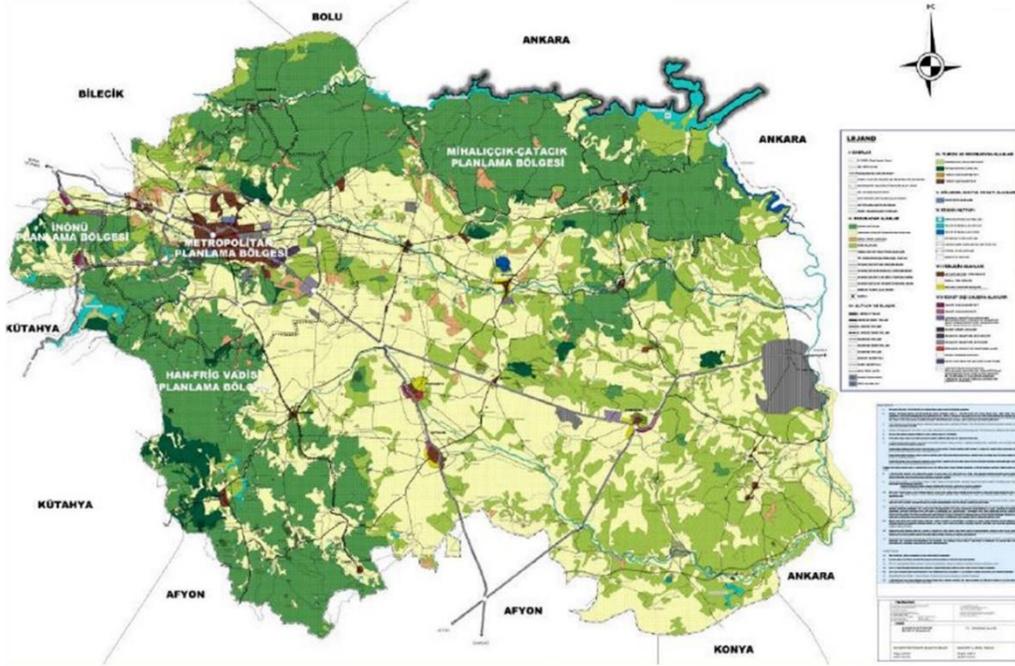


Figure 5-7 1/5000 Scaled Revision Development Master Plan of Eskişehir in 2002

➤ Eskişehir Environmental Plan in 2006

The city was analyzed into four groups in this plan and decisions were made in two different topics as conservation and development principles. Irrigation areas, agriculture areas, forest areas, water resources and archeological sites were put under

the protection by this plan with the conservation principles. Together with the development principles, development in service sector and tourism sector were envisaged and emphasizing these sectors in subscale plan was decided.



*Figure 5-8 1/100000 Scaled Eskişehir Environmental Plan in 2006
(Eskişehir Environmental Plan, 2006)*

➤ 1/25000 Scaled Master Development Plan in 2009

Besides industrial development, service sector was envisaged as an important focus point for the city in this plan. Present spatial characteristics of the city were created with and the plan boundary was changed by the Law for Metropolitan Municipality no 5216. Village transformed to neighborhood with this law. Their development areas were decided with this plan which suggested the sub-centers to supply the needs of center activities. However, this plan was cancelled after it is approved because the representation of plan had faults. Although it was an upper scale plan, there were lawsuits at a level of parcel.

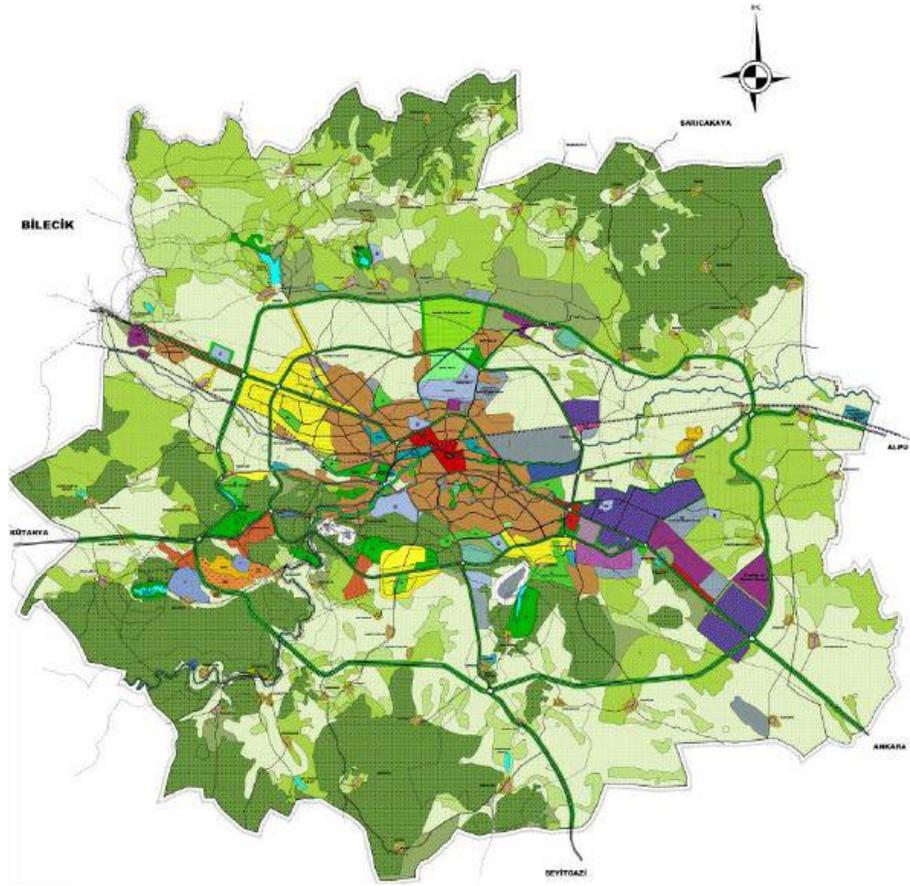
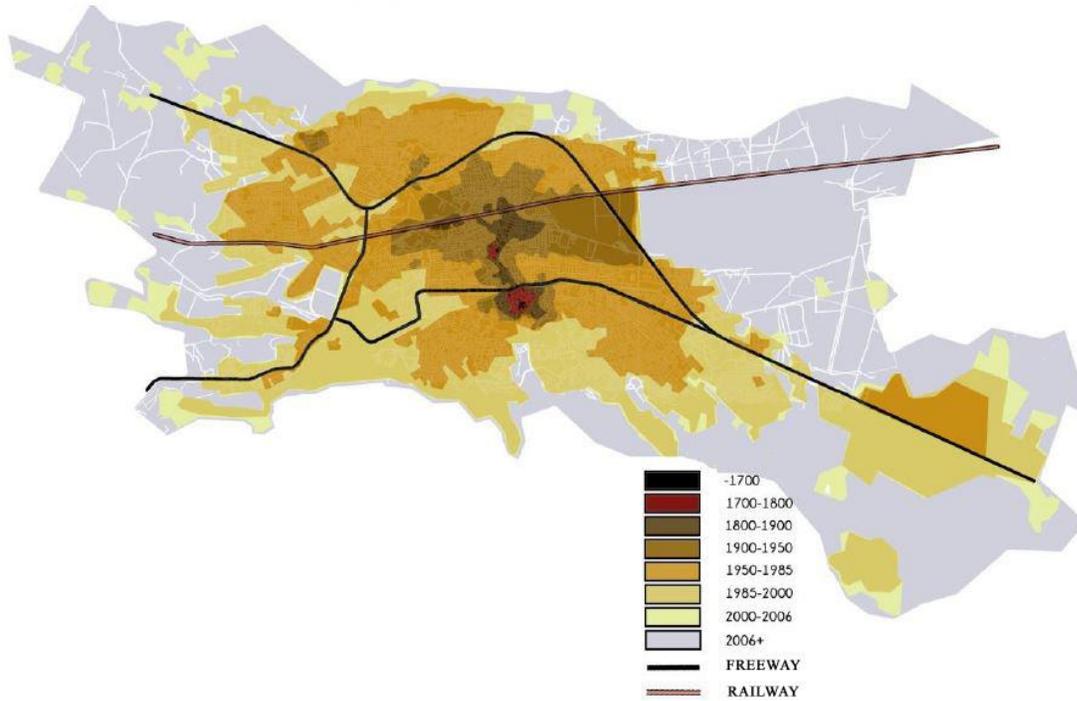


Figure 5-9 1/25000 Scaled Development Master Plan of Eskişehir in 2009

5.1.5 Development of Macroform

Since it was established, Eskişehir has developed fast in comparison with the other Anatolian cities despite of having difficulties. The city grew in the manner of economic, social and spatial. Thus, the city used its potential in a good way. On the other hand, when the spatial development of the city was analyzed, it can be seen that the development of the city was not a controlled development. Therefore, the master plans were prepared with a short time range because that plans had some contradictions such as planning standards and demographic analyses.



*Figure 5-10 Development of Macroform of Eskişehir
(Tepebaşı Municipality, 2016)*

When the macroform of Eskişehir is analyzed, it is seen that the city has two focus points where the connection of two points was provided. There are different developments affecting macroform such as railway station, industrial development and tram system. When the macroform and population movement are analyzed by the years, it is seen that as population exchange ratio is decreasingly grow and built footprint is also decreasingly grow. This situation shows that Eskişehir has stable sprawling and growing.

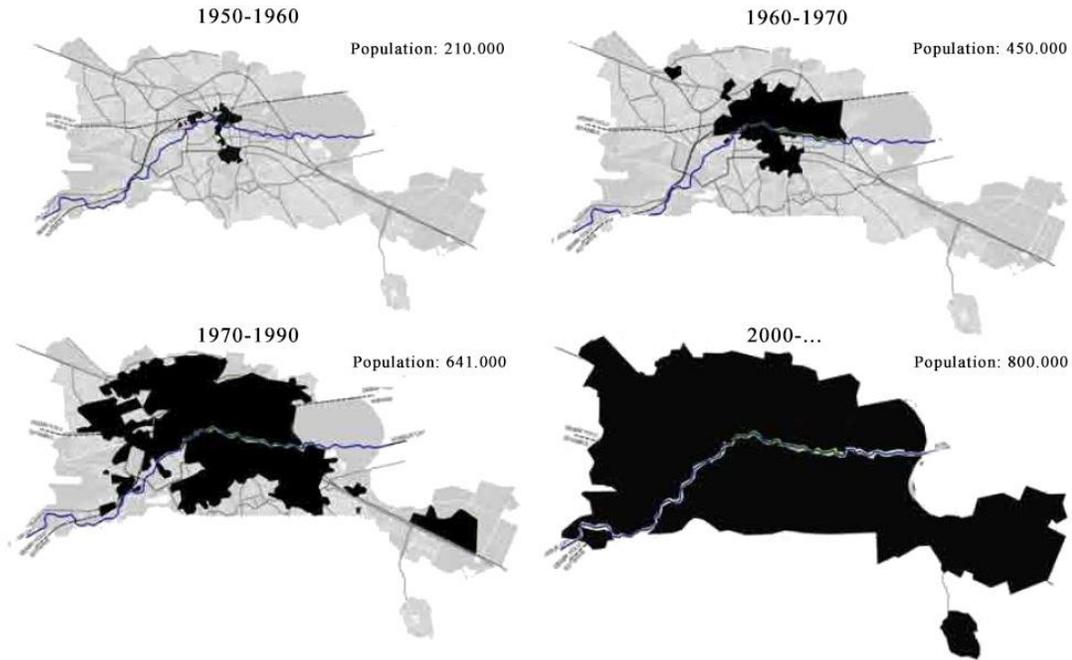


Figure 5-11 Development of macroform and population in different period (METU, CRP401 Planning Studio, 2014)

5.2 Modes of Transportation of Eskişehir: Tram System Oriented

5.2.1 General Information about Transportation System of Eskişehir

People use automobile, bus, minibus, tram (ESTRAM) and ESBOT⁴ for transportation in Eskişehir. According to surveys in 2009 (Eskişehir Metropolitan Municipality), daily travels with motor vehicles consist of 42% of travels for work and 21% of travels for education trip.

⁴ ESBOT is a boat on Porsuk stream and is used as a mode of public transportation between Kentpark and Köprübaşı

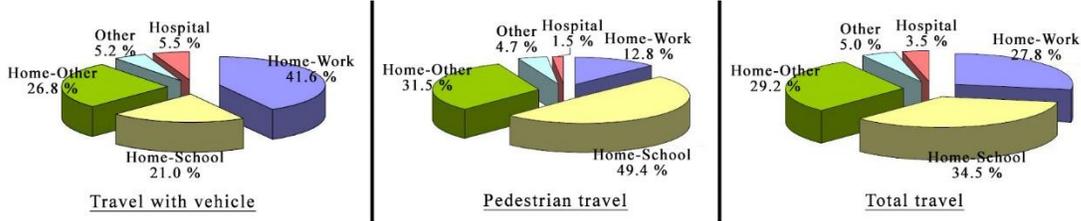


Figure 5-12 Distribution of travels with reference to the aims (Report of Eskişehir urban public transportation system, 2009)

When the daily usage of transportation modes is analyzed, the place of tram is on the top. While tram usage is 39%, bus has 26% percentage of daily usage (Eskişehir Metropolitan Municipality, 2009).

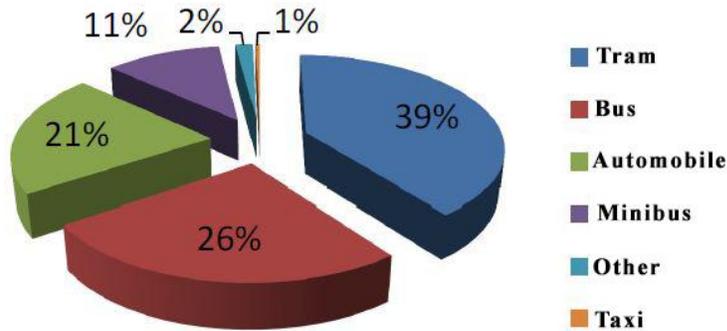


Figure 5-13 Distribution of daily travel modes Adapted from Eskişehir Metropolitan Municipality (2009)

According to the survey data, average time of the travel based on the aims of travel and the modes of transportation are shown on the Table 5-1. According to this table, in view of all aims and modes of transportation in Eskişehir, average time of the travel is 25.4 minutes. While it is 31.4 minutes for motor vehicle, it decreases 19.2 minutes for pedestrian (Eskişehir Metropolitan Municipality, 2009).

Table 5-1 Average travel time as a minute (Eskişehir Metropolitan Municipality, 2009)

Mode of Transport	Home-Work	Home-School	Home-Other	Other	Hospital	Total
Motor-Vehicle	32,2	30,8	31,2	28,0	31,5	31,4
Pedestrian	21,1	14,6	24,9	22,6	25,6	19,2
Bicycle	25,2	28,7	24,6	28,6	12,5	25,3
Total	29,5	19,6	27,8	25,5	30,2	25,4

As regards to the start and finish time of the travel of school and work, the distribution of the travels in a day is examined. According to this, 13.4% of daily morning travels starts between 07:15 and 08:15. In addition, 12,9% of daily evening travels starts between 17:15 and 18:15. Based on two-hour period, the peak hours are between 06:45 – 08:45 for morning and 16:45 – 18:45 for evening.

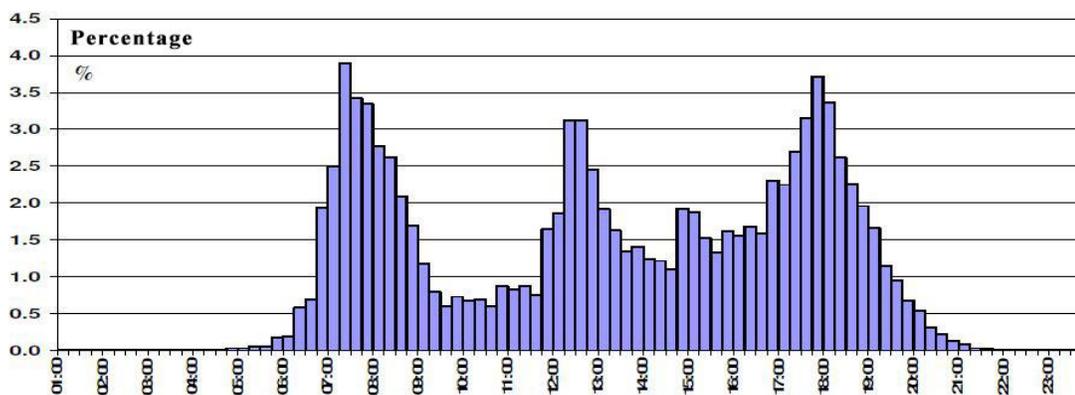


Figure 5-14 Distribution of total travels in a day as percentage (Report of Eskişehir urban public transportation system, 2009)



Figure 5- ISEskişehir urban transportation plan (METU, CRP401 Planning Studio, 2014)

5.2.2 Modes of Public Transportation

Buses, trams (ESTRAM), minibuses, taxi-dolmuş, taxis and shuttles are used for public transportation in Eskişehir. According to the report of Eskişehir urban public transportation system (2009), the most used systems are bus and tram. Therefore, information about the bus system and tram system (ESTRAM) are given in this part.

5.2.2.1 Bus System:

There are 49 municipality buses, 33 public buses belonging to ESULAŞ and 115 private public buses in Eskişehir. They are sharing 81 lines. There are 1108 stops on these lines. 170 buses run 1874 times in a day and each buses runs 11 times in a day. According to the data of 2011, 90.000 people use buses in a day and the details of trips are shown in the APPENDIX B.

Each bus has an electronic ticket system. According to 2009 data of automatic ticket machines, municipality buses carry 15.209 passengers, ESULAŞ buses carry 20.818 passengers and private public buses carry 50.517 passengers. It is seen that each neighborhoods especially the places where tram cannot accesses takes services when the accessibility to the bus is analyzed.

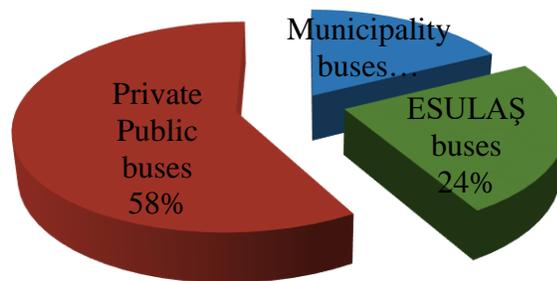


Chart 1 Percentage of carried passenger with buses (It is arranged from (Report of Eskişehir urban public transportation system, 2009))



Figure 5-16 Municipality buses lines (Erciyes University Department of City and Regional Planning,

5.2.2.2 Tram System:

Tram system, which connects the two universities- Eskişehir Anadolu University and Eskişehir Osman Gazi University- hospitals and center, has an important role for the urban transportation in Eskişehir. According to the transportation plan of Eskişehir, other public transportation systems and cycle ways are arranged as integrated with tram system. Before ESTRAM, people had generally used buses for transportation, however after ESTRAM, the usage of buses decreased. Chart 2 shows the changes between usage of the modes before and after ESTRAM.

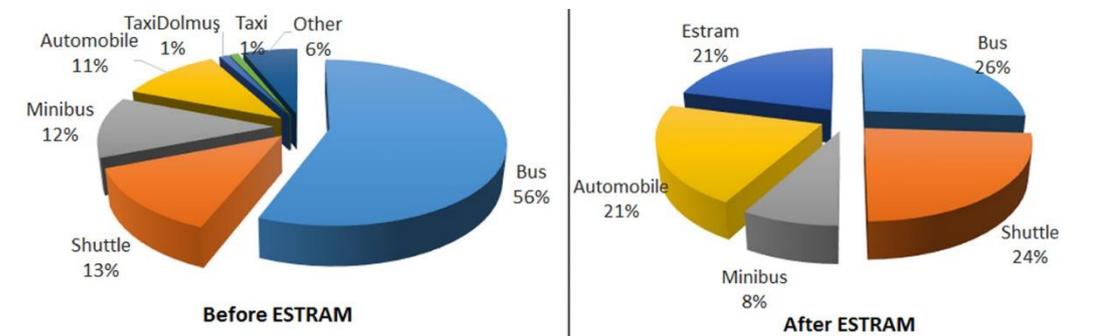
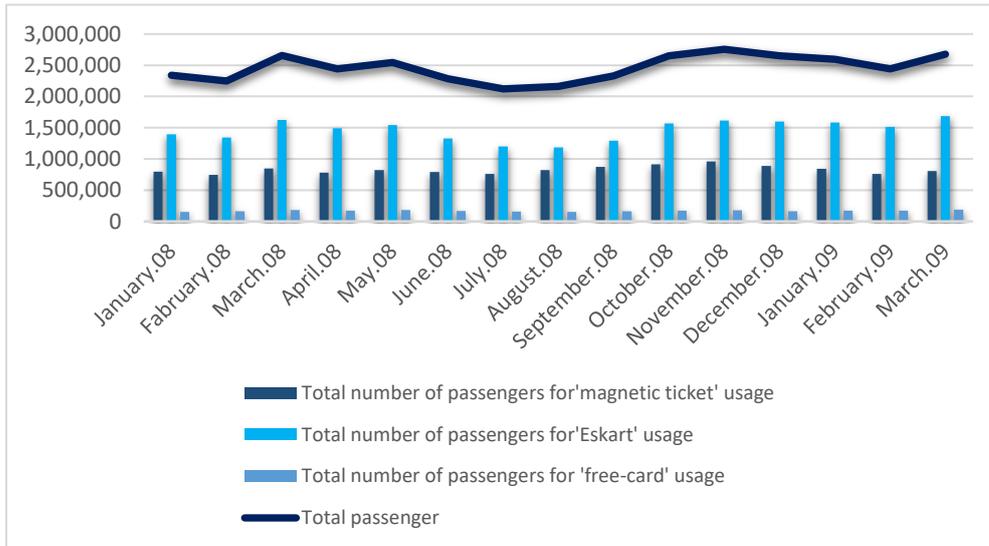


Chart 2 Usage of motor vehicle before and after ESTRAM (Eskişehir Metropolitan Municipality, 2009)

Transcurrent tramlines compound the northwest – southeast and southwest – northeast of the city. There are stops every 600 meters on the lines and stops have turnstile. The monthly average passenger numbers are about 2,5 million person. Graph 1 shows the monthly average passenger numbers according to the 2008 data. Today, tram system has 7 lines and 61 stops and the total length of the lines is 45km (Table 5-2).

Table 5-2 General view to Estram with numbers in a period between 2004 – 2012 (Estram Headquarters, 2012)

Total number of passengers	234.493.585 passengers
Average number of passengers in a week	99.013 passenger/day
Average number of passengers in a weekend	73.885 passenger/day
The number of line	7
The number of stop	61
Total km	45 km
Daily average km	4669 km
The number of vehicles	36
Total number of travels	1.432.848 travels
Daily average number of travels	562 travels



Graph 1 The monthly average passenger numbers (It is arranged from (Eskişehir Metropolitan Municipality, 2009))

Tram system, accomplished in two years, came on stream in 24th December 2004. The project of ESTRAM won the Light Rail World Award organized by International Association of Public Transport (UITP) (Estram Headquarters, 2012). The system has two lines which are called Otogar – SSK line and Osmangazi – Opera line. The track length was 16 km and there were 18 vehicles. The capacity

of tram was 210 people. The average passenger number changed between 75.000 and 90.000 in a day.



Figure 5-17 Estram lines (Estram Headquarters, 2012)

After two years from the first step of tram system, the second step of the tram project was started. 22km line and 27 stop was added to the first step of tram with the project of Emek, 71 Evler, Yenikent, Çankaya, Batıkent and Çamlıca.

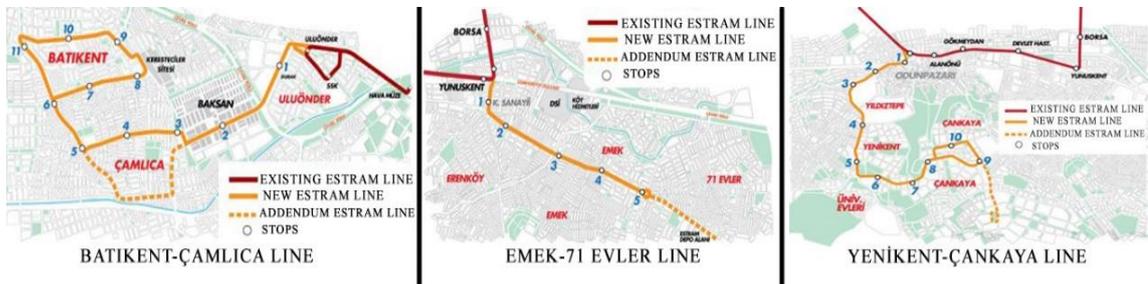


Figure 5-18 Steps of new projects of ETRAM planned in 2012 (wowTURKEY-Eskişehir-Estram 2.etap, 2012)

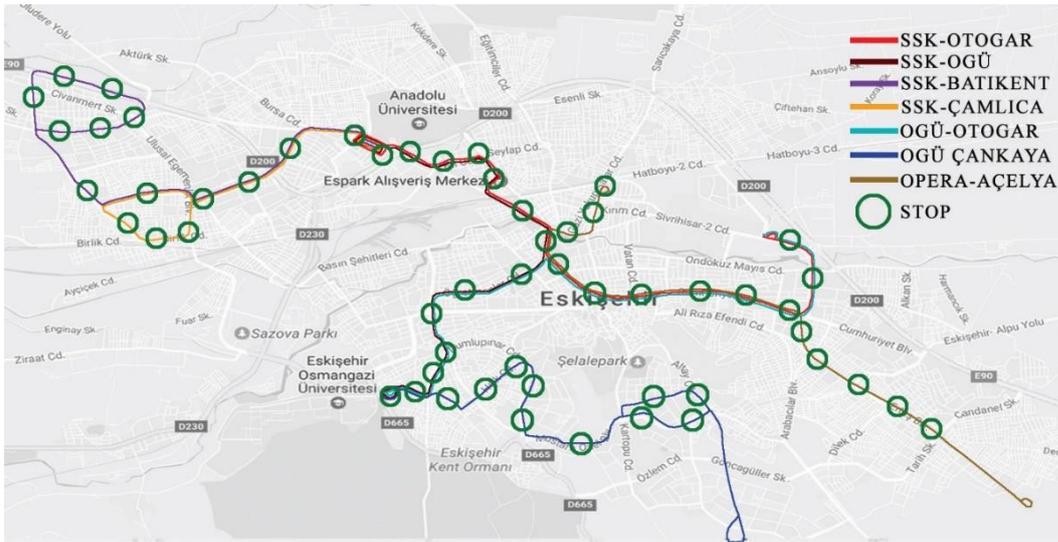


Figure 5-19 Additional tramline (Estram Headquarters, 2012)

After finishing the tram system, it had a huge role in public transportation. The construction of ESTRAM has affected both the automobile usage and the environmental factors such as air and noise pollution in a good manner.

There are two types of ticket for both ESTRAM and buses. Eskart and Esbilet have different prices. Table 5-3 shows the fee for both of them.

Table 5-3 The fees for Eskart and Esbilet used for ESTRAM and the buses.

	Eskart	Esbilet
1 riding for adult ticket	2.00 TL	2.70 TL
Transfer	0.30 TL	included
1 riding for discount ticket	TL	2.55 TL
Transfer	0.30 TL	included

CHAPTER 6

CASE ANALYSIS

6.1 Çarşı Stop and Its Environment, İstiklal and Arifiye Neighborhoods

Çarşı stop is located at the city center and situated on 2 Eylül Street which is located the intersection of İstiklal and Arifiye Neighborhoods. It is the main hub of public transportation. This stop is situated on the intersection of two cross rail of tram. Governmental buildings such as governorship and municipal building are located on these areas. For these reasons, it has become an essential commercial center of Eskişehir.

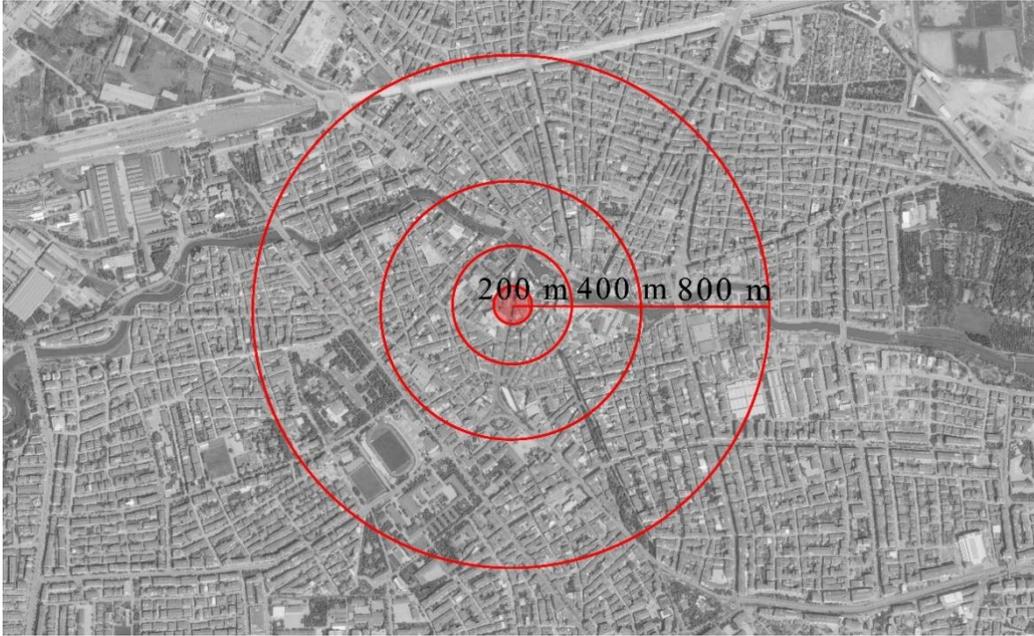


Figure 6-1 The analyzing area of Çarşı in the short and long walking distances (Personal studying)

These neighborhoods can be thought as the first settlements of the city in the history of republic. They were developed between 1923 and 1950. There are generally commercial activities. İstiklal neighborhood is determined as reserve area. It is found appropriate for commercial activities and it is decided that some commercial activities move to this neighborhood. There were 1-2 floor buildings in a garden but then they were demolished. 2-3 floor buildings were built along the street in these neighborhoods. However, there are still 1-2 floor buildings on back and side streets. İki Eylül Street is one of the important spines of the city having dual structure. There are commercial and public buildings so it can be called as a central street. While the first part of the street works with pedestrians and tram system, vehicular system and tram system work together on second part of the street. While commercial facilities are placed on the first part of the street, public and administrative functions are placed on the second part of it. The vitality of 2 Eylül Street is supported by public transportation and pedestrian flow. Pedestrianization projects for Espark and its environment provide the shifting pedestrian flow toward the north.

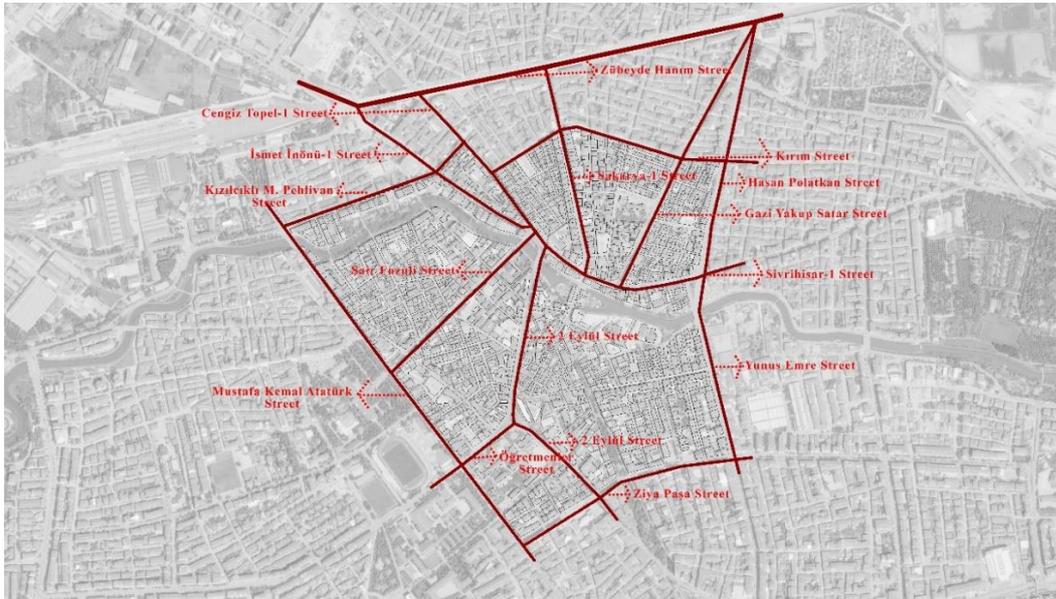


Figure 6-2 The main roads of Çarşı area (Personal studying)

6.1.1 Density

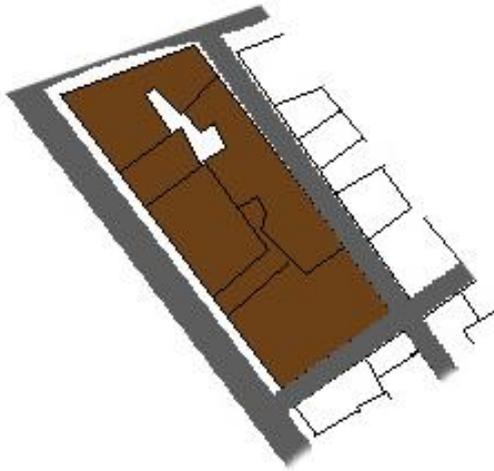
6.1.1.1 Physical Density

Çarşı stop and its environment have many historical places. Because of that, city blocks are smaller than the blocks other neighborhoods' have. However, this area is the center and it can be defined as high dense area. While evaluate the density of this area, the two neighborhoods' information should be analyzed because this area consists of two different neighborhoods (Table 6-1). Table 6-2 shows the density of a city block which has high-rise buildings on Mustafa Kemal Atatürk Street.

Table 6-1 Density of analyzed areas numerically (Personal studying)

Analyzed area	Neighborhood name	Population of the neighborhood	Area of the neighborhood (ha)	Gross density (person/ha)
Çarşı Stop	İstiklal	5.896	29	203
	Arifiye	6.235	32	195
Total		12.131	61	199

Table 6-2 Density of a city block on Mustafa Kemal Atatürk Street, Çarşı Stop (Personal studying)

	Average Number of Floors	6
	Population	453
	Area of city block	7000 m ²
	Building Coverage Ratio	0.88
	Floor Area Ratio	5.3
	Building Base Area	6400 m ²
	Net Density	708 person/ha
	Gross Density	630person/ha

6.1.1.2 Perceived Density

Perceived density is subjective term because it based on the personal intelligence. Building sizes, space between buildings, façade, and visual access to the open and green spaces influence the personal intelligence. According to this definition, Çarşı stop can be perceived as ‘crowded’ or high dense since this place is a center and a transportation hub.

6.1.2 Land Use and Diversity

Most of the users gather around Çarşı stop which is located at 2 Eylül Street because 2 Eylül Street is located at the center of Eskişehir. The Figure 6-3 shows the land use around Çarşı. While there are retail functions on the north of the street, administrative functions are on the south of the street. There are mix-used buildings on the inside of analyzing area. Restaurants, clothing stores, groceries, branch banks, advocate offices, dentists and buffets are located at the north of the street. Pedestrian circulation is comfortable and safe since the north of the street is close for the motor vehicles. On the other hand, pharmacies, restaurants, groceries and administrative buildings such as municipality buildings, government office, general directorate of Turkish post and banking directorates are located at the south of the street. There are restaurants, hunting material stores, clothing stores, groceries, tobaccos and hotels inside parts of the analyzing area. Moreover, retail functions are in sight along Sivrihisar-1 Street and İsmet İnönü-1 Street. Groceries, restaurants, banks, clothing stores and hotels are located along these streets. There are mix-used buildings on the north of Sivrihisar-1 Street and repair shops, hardware stores, restaurants and supermarkets are located in there (Figure 6-3).

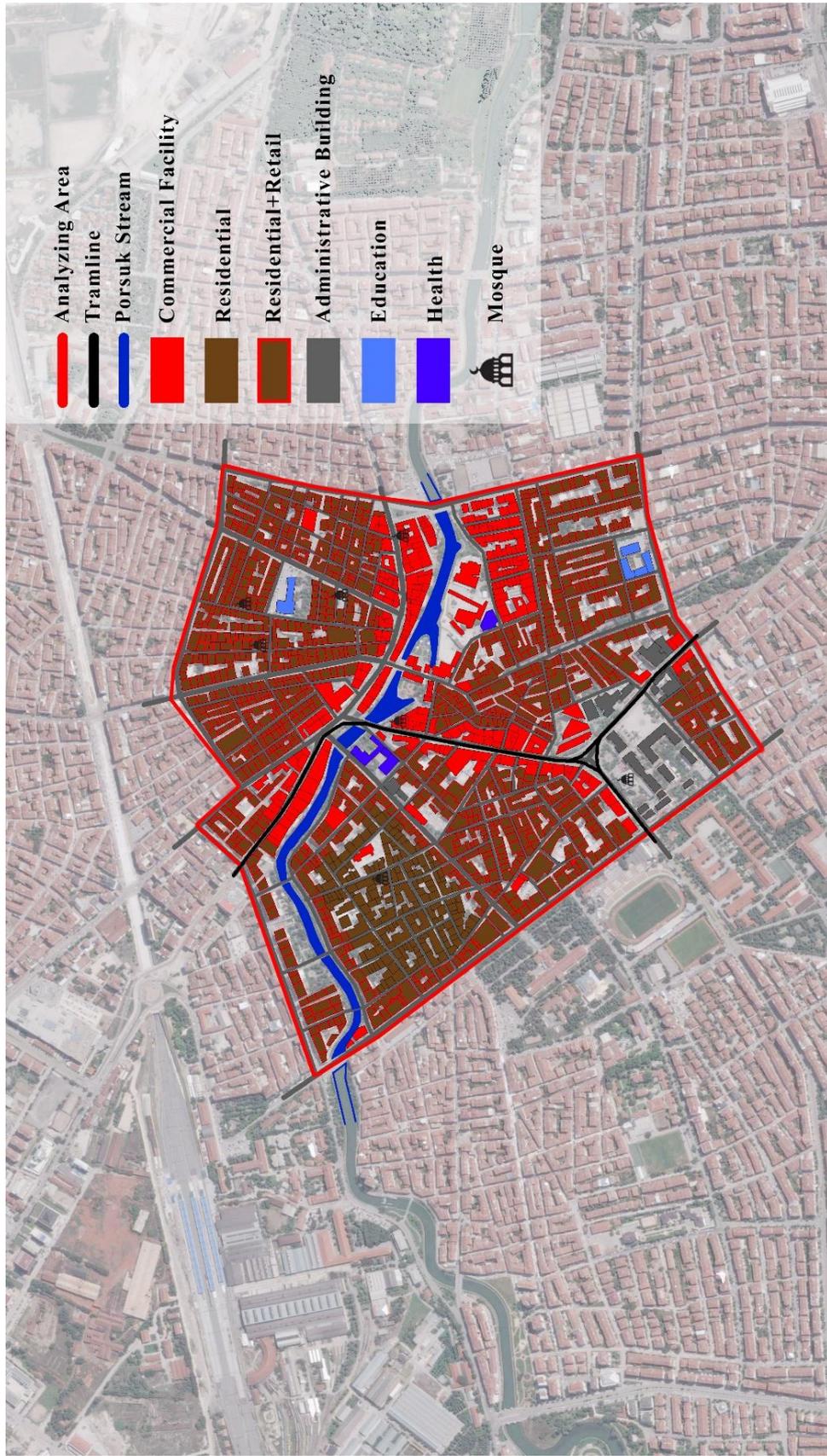


Figure 6-3 The current land use functions around Çarşı (Personal studying)

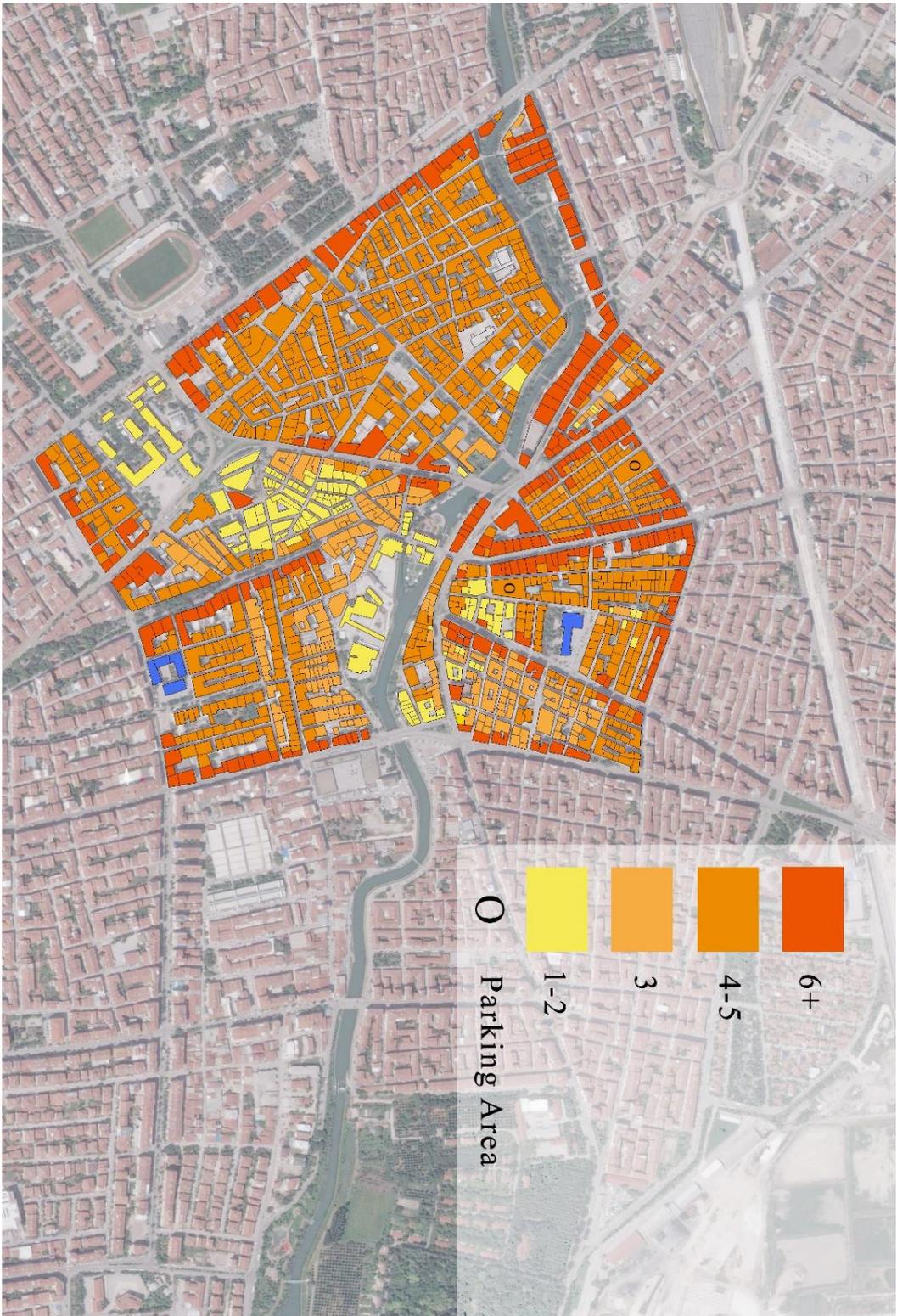


Figure 6-4 The current storey height on analyzing area (Personal studying)

Diversity is analyzed in terms of the scale of diversity, vertical diversity and horizontal diversity. Scale of diversity can be defined as a diversity which is homogenous in one scale while is heterogeneous in another scale. According to this, when the area is analyzed in macro scale, the function of area is central function. In other words, there are commercial, administrative and retail functions. However, when it is analyzed in micro scale, there are some residential areas besides the commercial, administrative and retail functions. Therefore, it can be said that while there are less diversity in macro scale, the area is more diverse in micro scale. On the other hand, vertical diversity is analyzed in terms of building height and floor functions. According to this, there are not high-rise buildings on the analyzing area because it is center of the city. While there are 4-5 storey buildings along 2 Eylül Street, 6 and more than 6 storey buildings are in sight along Mustafa Kemal Atatürk Street. While 4-5 storey buildings are seen intensely at the west of 2 Eylül Street, 1-2 and 3 storey buildings are seen at the east part of the street. Similarly, while 6 and more than 6 storey buildings are located at Sakarya-1 Street, 4-5 storey buildings are seen intensely inside part. According to these information, while 6 and more than 6 storey buildings are seen on the main streets, 4-5 storey buildings are at the west of 2 Eylül Street and the north of Porsuk Stream, and 1-2 and 3 storey buildings are seen intensely at the east of 2 Eylül Street. In addition, the function of storeys is different. For example, while the entrance floors have commercial functions, the other floors are residential on Mustafa Kemal Street. However, there are commercial, administrative and retail functions on the south of İki Eylül Street (Figure 6-4). Therefore, For Çarşı stop, the high-rise and low-rise buildings, and different floor functions are together in there. Because of this, it is mentioned about diversity within the scope of vertical diversity. Moreover, horizontal diversity is the last analyzing factor for diversity. It is analyzed in terms of land uses. Furthermore, if the area is analyzed in terms of land uses, it can be mentioned about mix used because the area is a center. Besides the buildings used as retail, it is seen that the usage changes by floor to floor. For this reason, vertical diversity can be seen more than horizontal diversity. However, when the north of the site is analyzed, horizontal diversity increases. Moreover, it can be seen people from different social

class because the area is a center and a transportation hub. Therefore, it can be mention about social diversity for Çarşı stop.

6.1.3 Accessibility and Connectivity

The north part of 2 Eylül Street which Çarşı Stop is located is closed to motor vehicle traffic so the ways to access here are tram or foot. All tramlines intersect on Çarşı stop. For this reason, this area is quite accessible. Each line frequency is 13 minutes. However, there are different transport modes to access to the other part of analyzing area. Bus, tram (streetcar), taxi, private car, bicycle and foot are the modes to access this area. There are parking areas for private cars. In addition, bicycle and motorcycle are also preferred transportation modes.

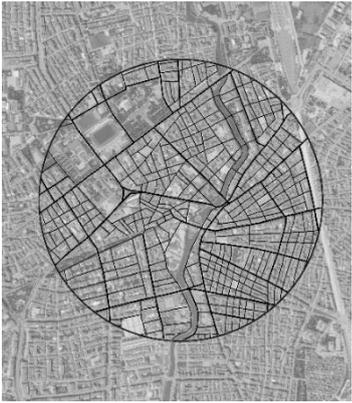
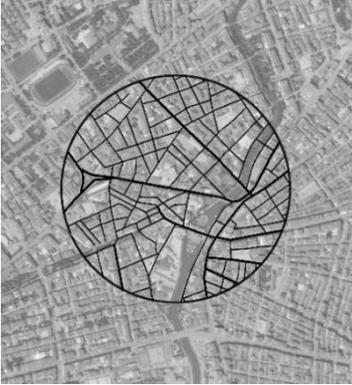
Table 6-3 Tramlines and times which the starting point is Çarşı stop

	Starting point	Destination	First tram	Last tram
Emek/71 Evler- Opera Line	Çarşı	Açelya	06:24	23:51
	Çarşı	Opera	06:07	00:11
Osmangazi- SSK Line	Çarşı	SSK	06:39	00:00
	Çarşı	Osmangazi	06:39	00:00
Otogar-SSK Line	Çarşı	SSK	06:00	00:04
	Çarşı	Otogar	06:33	00:38

When the area is analyzed within 800m, it can be seen that the connectivity is more. If the system of road network is grid, the accessibility increases. According to this, accessibility and connectivity are high in 800m for analyzing area. In addition, when the area is analyzed within 400m, it is seen that accessibility and connectivity are high. However, when it is analyzed within 200m, connectivity decreases because the city center was developed as walking oriented. For this reason, it is seen that the area around tram station within 200m is still walking oriented. In other words, car access is limited around the station. Under the circumstances, the city center – Çarşı stop area- has high accessibility and connectivity as walking oriented. Connectivity can be evaluated with connectivity index and intersection connectivity. High index shows the high connectivity. According to this, when the

Table 6-4 is analyzed, it is seen that connectivity index is higher within 400m from tram station. On the other hand, intersection index is higher within 800m from tram station. These indices shows that while there are high accessibility and connectivity with motor vehicle within 800m and 400m from tram stop, they decrease within 200m from tram stop because this area is more walkable. When the accessibility and connectivity is increaseing, the demand of public transportation increases. This situation shows that the city center is appropriate in terms of sustainable development.

Table 6-4 Accessibility and connectivity analysis for Çarşı area (Personal studying)

	800 m	400 m	200 m
			
Number of roadway links	34	11	3
Number of roadway nodes	29	8	0
Number of street intersection	192	74	21
Sum of number of intersection and cul-de-sac	146	65	19
Connectivity index	1,17	1,38	0
Intersection connectivity	1,31	1,09	1,11

6.1.4 TOD Design and Urban Design

6.1.4.1 TOD Design

Tod design guidelines support sustainable development. They provide walkable, mixed uses, imageable, enclosure, human scaled, transparent and complex areas. Although they are analyzed within urban design factors, they support to create TOD design guidelines. According to TOD design guidelines; the study area meets the all factors:

- City center is dominated by the office buildings.
- Parking lots are located within 800m from transit station.
- Activities increase the use, safety and sense of place.
- Pedestrian and cycling facilities keep alive around transit stations.
- There are human scale details such as street furniture and plantings.
- Street furniture provides social space for human.
- There are some visual elements for increasing attractiveness.
- Public spaces are appropriate for different users and activities in different times.
- There are eye-level streets which increase safety.
- Lighting is enough to provide visibility.
- There are no tunnels which decrease the level of safety.
- Streets and blocks provide multiple options for pedestrian moving from one place to another.
- There are landscape elements such as trees and flowers.
- Pedestrian area and driver area are distinguished from each other.
- Some traffic calming strategies such as speed bumps and different pavement are implemented for increasing the safety of pedestrians.



Figure 6-6 The left photo shows two important landmark around Çarşı stop and the right one shows Porsuk Stream being a natural edge (Personal archive)

b. Legibility

According to Lynch (1960), legibility increases with five elements explained in “Image of the city”. Each analyzing area is examined in terms of Lynch theory. According to this, it can be said that while Çarşı stop has more legibility. For Çarşı stop, paths are designed as grid system. Porsuk Stream can be defined as natural edge. Intersection points and the square in front of the government office are defined as node. In addition, Esnaf Sarayı, schools, sculptures on 2 Eylül Streets are the example for landmarks. It is easy to zoning based on land uses. For example, there are commercial facilities along 2 Eylül Street, Öğretmenler Street, Sivrihisar-1 Street and İsmet İnönü-1 Street.

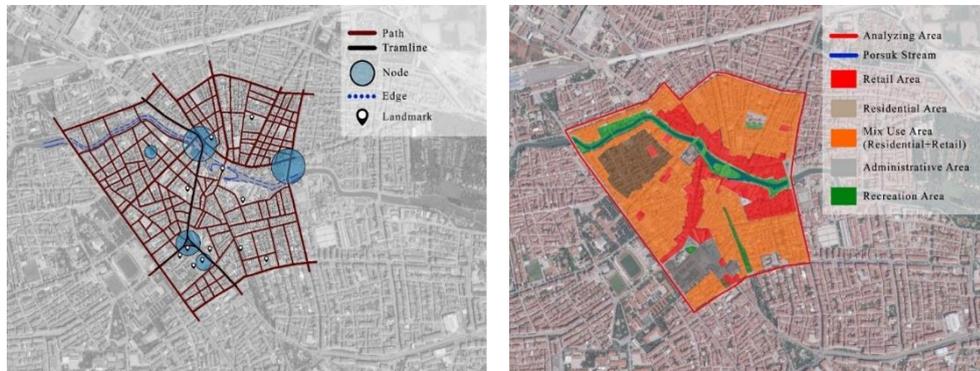


Figure 6-7 Legibility analysis for Çarşı stop. While the left one shows the paths, nodes, edges and landmarks, the right one shows the districts of Çarşı (Personal studying)

c. Enclosure

Çarşı stop and its environment can be defined as well enclosed. The north of 2 Eylül Street is a good example for the enclosure. Building height, street furniture, trees and shade elements are supporting the enclosure.



Figure 6-8 This photo shows street furniture, shade elements, building heights and pavements on the north of 2 Eylül Street (Personal archive)

d. Human scale

The size and form of physical elements should be proper to create human scale. Eye-level showcases, quantity of windows, gardens in front of the buildings and street furniture are some elements that provide human scale. For Çarşı stop, human scale is quite successful because of central characteristics. Showcases in eye-level, quantity of the windows, street furniture and trees increase the human scale factor.



Figure 6-9 This photo shows the example for human scale factor around Çarşı stop (Personal archive)

e. Transparency

While it is required the large showcases, cafes, restaurants, parks, schools and porches on footway to provide transparency for a commercial place, number of windows at the eye level and the absence of street walls are two factors that provide transparency for a residential place. For Carşı stop, there are many elements to provide transparency due to be a center. Large showcases on eye level, cafes and restaurants are some elements of this. In addition, active usage buildings provide transparency. Esnaf Sarayı, Municipality Building, Government office, Migros and Sebahattin Günday Park can be given as the example for the transparency elements.



Figure 6-10 Sabahattin Günday Park is an example for transparency (Personal archive)

f. Complexity

Visual richness increases the spatial complexity. Different building types, street furniture, lighting, park, plants and color are some elements that affect spatial complexity of the urban space. Variety of building heights, differentiation of buildings, different facades shows visual richness for Çarşı stop.

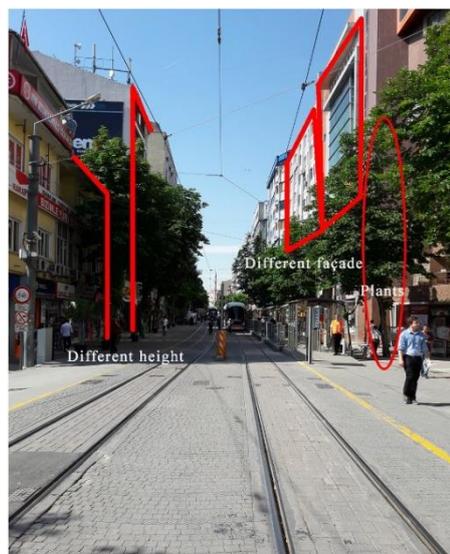


Figure 6-11 This photo includes different height of buildings, different facades and active usage of the buildings in Çarşı area (Personal archive)

6.1.4.2.2 Personal Factors

a. Sense of Safety

Active urban space is a way to reach actual safety. For Çarşı stop, this area is used more actively due to being a center. Shops which remain open till the late evening show that the time of usage of this place is long. Because of that, people feel safe in that place. Perceived safety is strong at the north of 2 Eylül Street because this part of the street is car-free zone. While narrow streets and footways are inside of this area make people feel insecure, the pavement of street, which is slow down the motor vehicle traffic, makes feel them safe against motor vehicle traffic. The sense of the safety is high especially in 2 Eylül Street because of the well-enclosed and eye-level street.



Figure 6-12 This photo is an example of safety. There are straight and continuous footway, slowed motorway with pavement and flower beds to prevent the pedestrian from the car (Personal archive)

b. Sense of Comfort

For the Çarşı stop, although the shade elements provide comfort on the main streets, they are not enough on side streets. This situation decreases comfort on rainy and sunny weather. While there are continuous pavement on the north of 2 Eylül Street, it cannot be said the same thing for other places. Pedestrian ways intersect with motor way frequently. This situation decrease the comfort level.



Figure 6-13 While there are shade elements, the footway is narrow on the photo (Personal archive)

c. Lighting

The lighting is perfect on the Çarşı stop because this area is one of the city's center. There are retail functions which increase the vitality of this area. The lights coming from the eye-level showcases and the streetlights are enough to provide lighting for this area.

6.1.5 Tram and Tram Design in Eskişehir

There are 7 different lines and 4 transfer points in Eskişehir (Figure 6-14). The distance between stops are approximately 500m. Low floor tram is used in Eskişehir (Eskişehir Metropolitan Municipality, 2011). The floor is 300-360 mm above top of rail. There are 5 tram stops around Çarşı area within 800m.

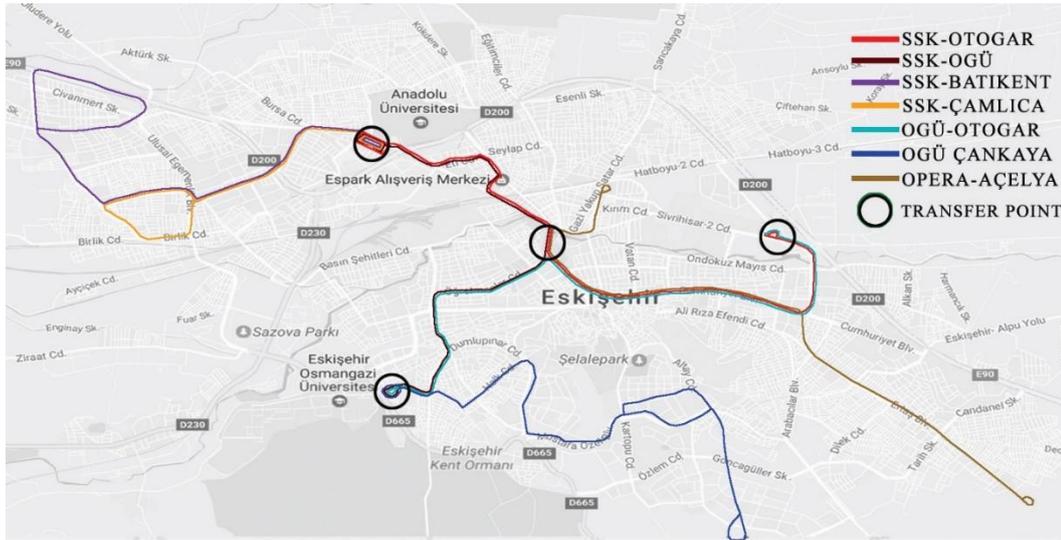


Figure 6-14 Tram lines and transfer points in Eskişehir (Personal studying)

Tram stops have platforms which make easier to take into the tram vehicle. Each tram stop has a shelter with sitting places, tram line map, advertisement space, and barriers for protecting the passengers. All the tram stops have ticket machines with turnstiles. While some stops have officer and officer cabinet, some of them have not however officers control the tickets in tram vehicles on any stop. Lighting and signs are important for increasing the visibility of these stops and safety of the passengers.

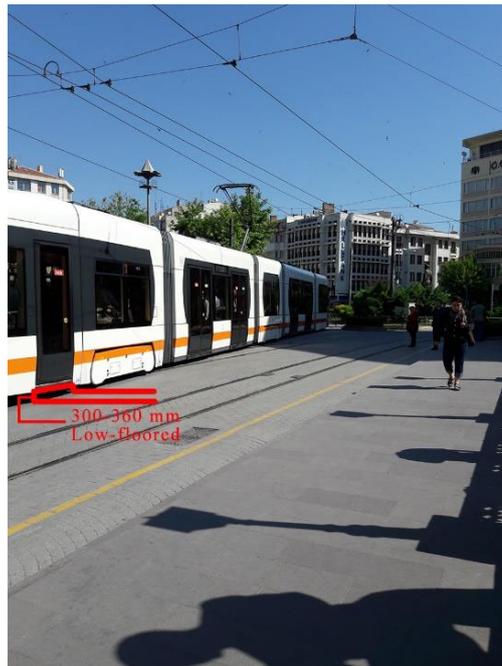


Figure 6-15 Low floor trams are used in Eskişehir (Personal archive)



Figure 6-16 Tram stops design in Eskişehir (Personal archive)

CHAPTER 7

CONCLUSION, EXPOSITION AND RECOMMENDATION

7.1 Conclusion

The starting point of this study was to analyze the factors increasing the public transportation demand which have been debated in recent years. This issue has significance in the point of creating sustainable cities. TOD is one of these tools which entered the planning terminology in the late 80s. It has encouraged residential and commercial areas around public transportation stops and decreased the usage of automobile. For this reason, many planners and specialists proposed different methods such as transit oriented development and pedestrian oriented design. However, when TOD was implemented, the connection of the areas was not taken into account. This is because the designing tools were not considered as important in this regard. Although these methods were successful when they were judged on their own merits, they are not enough to create a sustainable urban. Because of this, the methods and urban design factors should be thought together. In this thesis, it is tried to be explained that TOD and urban design are complementary concepts. Urban design factors should be used correctly in order to create successful TOD. Therefore, study was conducted to answer this main question: “How public transportation demand can be increased by combining the factors of TOD and urban design?”

Based on the main idea of the study, the impacts of TOD and urban design are important to be handled together for creating sustainable city which is a new urbanism tool. First of all, new urbanism was analyzed to understand how the term of sustainability occurred. Within this context, emergence of the term, effects to the city and principles of the new urbanism that support TOD and urban design were analyzed.

Secondly, there is literature review about TOD. This review contains the definition of TOD, transportation modes, advantages and challenges of TOD. While Cervero

and Kockelman (1997) examine the TOD in terms of density, diversity and design which are mentioned as 3Ds of the city, Litman (2012) claims that the accessibility and connectivity are important in the analyzing of TOD. For this reason, the factors of TOD were analyzed into three parts as density, land use & diversity and accessibility & connectivity. Density which is defined as a number of units was explained from two perspective as physical density and perceived density. After this analyses, it can be said that density has significance in the point of increasing public transportation demand. On the other hand, land use and diversity were also important for TOD because they have many benefits at different points such as vitality, creation of the centers with better quality, reduction of car dependency and increase of the public transportation usage. Diversity is a complex term that can be analyzed as social, economic, physical and temporal. However, mixed-use was the most important category in the thesis because the effects of diversity increase when the mixed-use area increases. Accordingly, land use, vertical diversity and horizontal diversity were analyzed within this context.

Another study which is significant for this thesis was TOD design and urban design. TOD design and methods were explained under TOD design topic. After the research for TOD design, design guidelines were constituted. According to these guidelines, it was seen that they include urban design factors. Consequently, it would not be wrong that TOD and urban design are complementary concepts. On the other hand, urban design and its factors were analyzed to understand TOD factors and its importance for TOD. For this reason, urban design and objectives of urban design were defined. These objectives included the factors of urban design. Moreover, the development of urban design and its effects on the cities were explained. There can be found the effects of new urbanism under these explanations. In addition, factors of urban design were analyzed in two parts as physical factors and personal factors. While physical factors were defined as objective, personal factors were defined as subjective. These factors were separately explained and to clarify them clearly, some figures were used. Additionally, in order to clarify these factors, some practices regarding the urban design in TOD and the transit station were given. In this context, different cities

within walking distance (200m – 400m) were also examined in terms of land use & density, diversity, accessibility, connectivity and streetscape & environment with related figures. In addition, tram and tram design were analyzed and the development of tram were explained within this framework. Moreover, factors of tram environment and stop design were explained. Dimensions of vehicles, furniture for the stops and factors for the stops' environment for useful tram system were defined.

In order to prepare this theoretical background, various books, many articles and reports about new urbanism, TOD and urban design were examined. This study demonstrates that there is a deficiency about the combination of TOD and urban design. The result of this study showed that TOD and urban design were complementary terms and urban design should be considered when TOD is implemented for the city.

7.2 Exposition

The main purpose of the case study is to gather the literature review. The main question of the thesis was replied by explaining the literature review with the case study. When new urbanism was analyzed, it was seen that TOD and urban design were tools for creating sustainable city. Therefore, TOD was not enough for creating sustainable city. For this reason, TOD and urban design should be evaluated together. In addition, tram system which was defined as the easiest and most comfortable public transportation mode have gained importance recently. Therefore, this thesis was written as tram oriented.

According to the literature review, the case area has capital importance. Eskişehir is the best city in Turkey as an example within the context. Çarşı area which is the intersection point of tram system and city center was selected as a study area in order to emphasize tram system. This area developed as pedestrian oriented because it is one of the first settlement places in Eskişehir. Although the number of car owners and public transportation vehicles has increased with the development of motor vehicle, Çarşı area stayed as pedestrian-oriented. Different public transportation modes have been integrated on this area in time. For these reasons, it

has been expected that the area has the TOD factors when it was analyzed. However, tram stop environment and stop design should be analyzed within walking the distance because design is an important factor to improve TOD.

Analysis shows that the area had the factors of TOD and design which are expected. According to this, when the analysis is examined, there can be reached to the following information about the area. First of all, according to TOD design and urban design factors, the area is expected to be high dense. It is seen that Çarşı is a high dense area both physically and perceptively. In addition, mixed-use and diverse areas are expected. Therefore, it is seen that Çarşı has different land uses. There is retail, office, administrative and residential usages. In addition, there are both vertical and horizontal diversity. In other words, functions of each floor of buildings are different and functions of building distribute vertically. This situation supports TOD design. Moreover, when accessibility and connectivity are analyzed, it is seen that the area has a well connection and accessibility as it is expected because the area is center of the city and it should be accessible. However, when these factors are analyzed within different walking distance, it is seen that the connection is least within 200m because the ratio of pedestrianization is high in this area. On the other hand, TOD design guidelines and urban design factors include each other. The area is analyzed within this context, it is seen that Çarşı provides all essential factors. Furthermore, when tram stops and vehicles are analyzed, it is seen that Eskişehir has high quality stops and vehicles. Stops are accessible by all people such as people with wheelchair and pushchair. In addition, there are automatic barrier to preserve people from tram vehicles and also officers to control people. The output of this analysis can be seen on Table 7-1.

As a consequence of literature review and case study, it can be said that TOD is not effective alone. It should be provided with design factors to increase vitality, walkability and sustainability of the area. While TOD increases the accessibility and the usage of the area by providing public transportation, design ensures high vitality and walkability around station within walking distances. When the area is analyzed according to them, the area can be defined as TOD center. Furthermore, the area is well designed. When these two characteristics are integrated, it is seen

that TOD has strong effect. This situation increases the public transportation demand. However, it should not be ignored that Çarşı is a center and it is expected to provide these factors because of central characteristics.

Table 7-1 Summary table

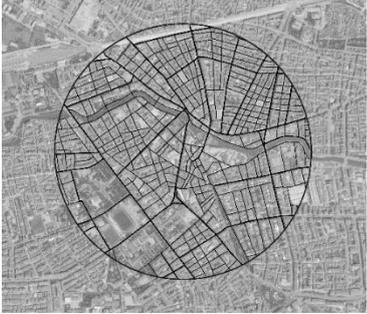
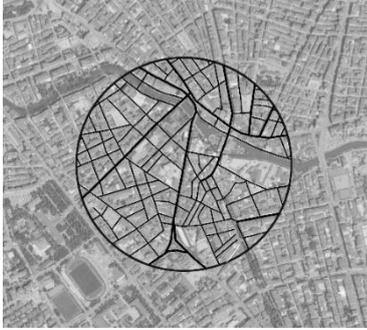
Location of area		Center of the city
Transportation modes		<ul style="list-style-type: none"> - Bus - Tram - Taxi - ESBOT - Private car
Population of the neighborhoods (İstiklal and Arifiye)		12,131
Physical density		199 person/ha
Perceived density		High
Land use		Mixed land use
Diversity		High
Accessibility		High
Connectivity	800 m	
	400 m	

Table 7 -1 (Continued)

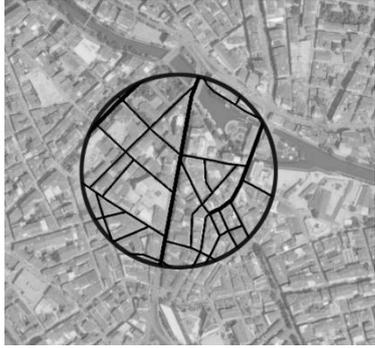
	200 m	
Connectivity index	800 m	1.17
	400 m	1.38
	200m	0
TOD factors	Office buildings	High
	Parking lots	High
	Activities	High
	Pedestrianization	High
	Street furniture	High
	Landscape elements	High
Urban design factors	Imageability	High
	Legibility	High
	Enclosure	High
	Human Scale	High
	Transparency	High
	Complexity	High
	Sense of safety	High
	Sense of comfort	High
	Lighting	High

Table 7 -1 (Continued)

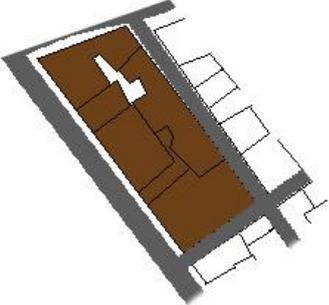
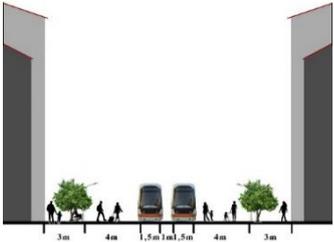
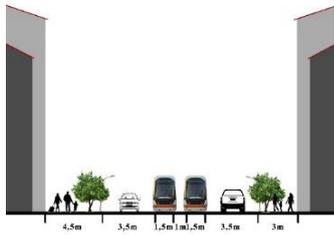
<p>General housing pattern</p>		
<p>Section</p>	<p>The north of 2 Eylül Street</p>	
	<p>The south of 2 Eylül Street</p>	
<p>Elevation</p>	<p>Retail</p>	

Table 7 -1 (Continued)

Elevation	Mixed use	
Tram type		Low floor
Distance between tram stops		500 m
Walkability between tram stops		High
Tram stops	Platforms	Exists
	Shelter	Exists
	Sitting place	Exists
	Barriers	Exists
	Ticket machine	Exists
	Lighting	High
	Safety	High
	Comfort	High
Tram stops		
		

7.3 Recommendation

The term of sustainability has gained importance with the effect of New Urbanism recently. TOD is one of tools of the New Urbanism. However, when it is implemented, urban design is ignored. Because of this, TOD cannot reach the success in an intended level. This situation was explained in the thesis and it is emphasized that TOD and urban design should be thought together.

This judgement was tried to explain with case study and the case study lent credence to this judgement. However, it should not be disregarded that Çarşı area which was chosen for the case study is a center of the city. Public transportation stops which are located in the center are good examples for using TOD and urban design together. Nevertheless, when it is taken into account for an entire city, this situation gets change. Implementing the factors of TOD and urban design simultaneously is difficult especially in residential areas. The effects of these factors decrease in these areas. This situation affects the success which is intended in a negative way.

On the other hand, tram is a strong tool which dominates the development of a city. Most people find it nostalgic and they use it. Trams pick up speed and their comfort level increases owing to today's technology. For this reason, trams are one of the most preferred public transportation modes in a city. The cities should be developed by using these advantages of tram. Additionally, not only the central areas but also the residential areas should be developed by the factors of TOD and urban design that were explained in this thesis. In order to reach the success in the residential areas, there should be created niches around stops. People should be encouraged for using public transportation by increasing urban design factors. Mixed-use areas should be increased around stops. Moreover, it is seen that people prefer public transportation when the safety and vitality levels increase.

Therefore, when TOD is implemented with the aim of creating sustainable city, not only TOD but also urban design factors should be considered for creating sustainable city. These factors are sometimes ignored for increasing rent. However, sustainable development of the city is more important than the rent. Under these circumstances, some legal tools should be use for restraining this negative situation.

Thus, obstacles which are encountered in urban development period should be clear. It should not be forgotten that public transportation system and urban design which are well-conceived encourage people to use the public transportation. This situation reduces the automobile usage while increasing the urban sustainability.

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APPENDICES

APPENDIX A

Example of urban design dimensions of TOD (Jacobson Forsyth 2008)

	Dimension	Example guideline or approach	Comment
Processes	<i>Time</i>	Design with short-term and long-term timeframes in mind, because places, the people who visit them, and the activities visitors perform change over time. The possibility of future growth should also be considered. In addition, good design allows to use change easily over time.	Little discussion about managing design character over development periods that can last decades.
	<i>Engagement with public</i>	Include various stakeholders in the design stage and use visioning and communication processes to elicit design ideas and create the design plan (Dunphy, Myerson, & Pawlukiewicz, 2004, p. 171)	While broad public participation is celebrated in the academic literature, there is little research on very diverse publics, however.
	<i>Programming</i>	Programming means planning events and activities in public spaces. For example, concerts, flea markets, farmer’s markets, art shows, outdoor theatre and the like help “bring people and vitality to the area” (Dunphy, Myerson, & Pawlukiewicz, 2004, p. 171)	There is much discussion about mixed use and street life, much less on programming.

	<i>Maintenance</i>	Understanding and budgeting for maintenance requirements, especially in terms of landscaping and greenery, should be part of the design process.	
Places	<i>Scale</i>	Emphasize design at a human scale, meaning one based on comfortable walking distances between points. Specifically for TOD, this means development within a quarter mile or a five minute walk radius (doubled for major stops) with placement of homes near transit at sufficient density; provide transit supportive regional design (Seigman, 2003; Dittmar & Ohland, The New Transit Town: Best Practices in Transit-Oriented Development, 2004).	This is a key dimension; the focus is environments where uses are close together rather than the finer grained issue of design of buildings and spaces to be human-scale.
	<i>Public spaces for human use</i>	Individual parts of the overall design should be designed with human activity in mind with “public spaces the focus of building orientation and pedestrian activity” (Calthorpe, 1993, s. 43; Dittmar & Ohland, 2004) (Dittmar & Ohland, 2004; Seigman, 2003)	Focus is on urban form rather than design details.

	<i>Safety</i>	Safety is a foundation of creating inviting public spaces and can be addressed through a variety of mechanisms. These include physical measures such as good lighting to avoid dark spots and encouraging “a variety of residential uses to ensure round-the-clock activity” (Dunphy, Myerson, & Pawlukiewicz, 2004, p. 176)	
	<i>Variety and complexity</i>	Attractive public spaces tend to be diverse, colorful and interesting ones that avoid monotony, either in terms of how they look or how they are used. Designers should pay attention to the social, visual, and land use dimensions of complexity in the design process (Dittmar & Ohland, 2004). Development and planning approaches should “encourage every price point to live around transit” (Dunphy, Myerson, & Pawlukiewicz, 2004, p. 176)	Variety and complexity includes social, land use, and visual dimensions though these may need different design supports
	<i>Connections</i>	Average block perimeter limits (Seigman, 2003) (proposed 400m) to create “a fine-grained network of streets, dispersing traffic and allowing for the creation of quiet and	Pedestrian-friendly street networks are a major focus of TOD guidelines.

		intimate thoroughfares” (Calthorpe, 1993, s. 43)	
Facilities	<i>Pedestrian/non-motorized orientation</i>	Signal timing, traffic calming, etc. support non-motorized transportation. Attended bike stations at major stops; secure parking at more minor stops (Seigman, 2003).	Transit development needs to support access from non-motorized modes.
	<i>Transit in the urban pattern</i>	Transit stops should be “attractive, comfortable, and sheltering” as well as well-located (Dunphy, Myerson, & Pawlukiewicz, 2004, p. 180).	Bus and train transit connections can be key (Dunphy, Myerson, & Pawlukiewicz, 2004).
	<i>Car movement and parking</i>	Minimum parking requirements are eliminated; maximum parking requirements are added (Seigman, 2003).. Other options include shared and structured parking (Dunphy, Myerson, & Pawlukiewicz, 2004)	Authors vary in how motorized modes should be accommodated.

APPENDIX B

Details of bus trips

Line no	Vehicle no	Lines from...to...		Trip no	Headway(min.)
1	4	Çankaya	Bademlik	66	15
2	2	Yeşiltepe	Tıp	20	45
2	2	Yeşiltepe	Sönmez kent	20	45
3	2	Ertuğrulgazi	S.S.K	29	30
3	2	Ertuğrulgazi	Tıp	25	*
4	2	Tunalı	61 Evler	30	30
4	4	Yıldız	2 Eylül Kampüsü	77	10
5	3	Zincirlikuyu	Odunpazarı	38	*
6	4	Odunpazarı	Organize Sanayi	42	20
8	2	Esentepe	Tıp	22	40
8	2	Sakintepe	Devlet Hastanesi	23	40
9	3	Sümer	Terminal	36	25
10	2	Ihlamurkent	Terminal	20	45
10	2	Çankaya	Terminal	20	45
11	2	Orhangazi	Odunpazarı	29	30
11	2	Karacaşehir	Odunpazarı	29	30
12	2	Fevziçakmak	Devlet Hastanesi	30	30
12	1	Fevziçakmak	S.S.K	15	60
13	2	Tıp Fakültesi	Terminal	25	35
14	6	Gündoğdu	Tıp	65	10
15	2	Emek	Devlet Hastanesi	57	15
16	2	Çamlıca	Odunpazarı	29	30
16	3	Çamlıca	Odunpazarı	43	20
17	2	Sazova	Odunpazarı	29	20
17	1	Ömür	S.S.K	15	60
18	2	Terminal- Gültepe	Tıp	25	35

Line no	Vehicle no	Lines from...to...		Trip no	Headway(min.)
18	2	Terminal	Üniversite Evleri	24	35
19	7	Şirintepe	Tıp	63	*
20	2	Kuyubaşı	Odunpazarı	29	30
22	1	Bademlik	Tıp	14	60
23	6	Batıkent	Tıp	46	*
24	2	Tıp Fakültesi	K.Evi-Mamuca-S.Sungur	22	*
24	1	Mamuca	Tıp	12	40
25	2	71 Evler	Terminal	20	45
25	2	71 Evler	Tepebaşı Camii	20	45
27	2	İstasyon	Tıp	30	30
29	5	Uluönder Neo	Terminal	43	10
30	1	Terminal	Yenikent	14	60
31	1	Karabayırbağları	Odunpazarı	14	60
32	5	Yenikent	Akademi	62	*
33	1	Kartal Evleri	Devlet Hastanesi	15	60
34	2	Üniversite	Yenikent-Tıp	29	30
35	2	Şirintepe	Odunpazarı	38	20
36	3	Tıp Fakültesi	Keskin	23	40
37	4	Ihlamurkent	Metal İş Blokları	28	30
38	1	S.S.K-B.Oğlu	Çamlıca	15	60
39	2	Ölçe Sitesi	Tepebaşı	19	50
42	1	Gündoğdu	Tıp	11	80
43	4	71 Evler	Tıp	45	40
44	1	Sultandere	Terminal	15	60
44	4	Sultandere	Tepebaşı	33	*
44	6	Sultandere	Tıp	48	*
48	2	Emek	2 Eylül Kampüsü	20	45
48	2	Emek	Tepebaşı Camii	20	45
50	2	Satılmış	Odunpazarı	19	45
51	2	S.S.K	Terminal	19	45
53	1	Uludere	Odunpazarı	5	*

Line no	Vehicle no	Lines from...to...		Trip no	Headway(min.)
54	6	Batıkent	Tıp	45	*
57	1	Devlet Hastanesi	Kanlıpınar	14	60
58	4	Çukurhisar	Odunpazarı	31	30
59	2	Muttalip	Odunpazarı	29	30
60	1	Odunpazarı	H Tipi Ceza Evi	6	*
62	1	Odunpazarı	Hekimdağı	3	*
63	2	Ihlamurkent	Sıraevler	20	45
63	2	Ihlamurkent	Sıraevler	20	45
64	1	Şehir	Kulüp	3	*
65	1	Türkmentokat	Odunpazarı	5	*
66	1	Karapazar	Odunpazarı	2	*
67	1	Yukarıçağlan	Odunpazarı	4	*
68	1	Ağapınar	Eski Otogar	4	*
69	1	Kavacık	Odunpazarı	5	*
70	1	Cumhuriyet	Devlet Hastanesi	5	*
71	1	Süpren	Odunpazarı	2	*
72	1	Odunpazarı	Yeni Sofça	2	*